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VORTEX FLOW THROUGH HORIZONTAL ORIFICES^a

Closure by J. C. Stevens and Richard Kolf

J. C. STEVENS,¹ M. ASCE and RICHARD KOLF,² J. M. ASCE.—In addition to the published discussions of this paper there were received a number of inquiries by mail regarding certain features of the Portland vortex interceptor diversions. The most important concerned the orifice coefficients of flow used in the design of the diversions.

Table I is a sampling of the design data. No flow coefficients were applied. The orifices were made in standard sizes matching standard sewer pipe sizes. It will be noted that the orifice diameter is from 2 to 4 inches less than that of the diversion interceptor. The object was to insure a vortex through the orifice for all high flows, while all other flows would pass through the orifice anyway with or without appreciable vortices, due to the small dam in the sewer just below the orifice chamber.

We learn from our failures more than from our successes. The vortex flow for combined sewer diversions was so eminently successful that the senior author decided to try a vortex for the separation of gas from mineral water.

A company for whom the senior writer is the engineering consultant, operates plants in Oregon and Washington for the manufacture of dry ice and liquid CO₂. The gas is found in heavily charged water and is obtained by pumping into a separator from drilled wells. This is merely a vertical concrete structure sealed at the top while the escaping effluent maintains a water seal at the bottom.

The pump discharge pipe passes through the separator wall some 8 ft. above the bottom. The gas is recovered by spraying the pumped water onto the inside face of the structure wall. The gas is drawn off through a pipe sealed in the top and connected to the suction side of an air compressor in the distant plant. This maintains a vacuum of about 6 inches of mercury in the pipe line and the interior of the separator.

Fig. 12 is a sketch of the vortex chamber sealed into the top of the separator with the gas line sealed into its top. On test a very vigorous vortex was formed, but the gas recovery was no more than had been previously obtained very cheaply with the old nozzle spray! To obtain more gas the separation chamber would have to be under a much greater vacuum and perhaps heating the water also—both impracticable.

Mr. Cunningham suggests there may be other practicable applications of vortex flow. Any kind of solids in air, water, smoke or any mixed fluids of

a. Proc. Paper 1461, December, 1957, by J. C. Stevens and Richard Kolf.

1. Cons. Engr., Stevens & Thompson and Leupold & Stevens Instruments, Inc., Portland, Ore.

2. Asst. Prof. of Fluid Mechanics, Marquette Univ., Milwaukee, Wisc.

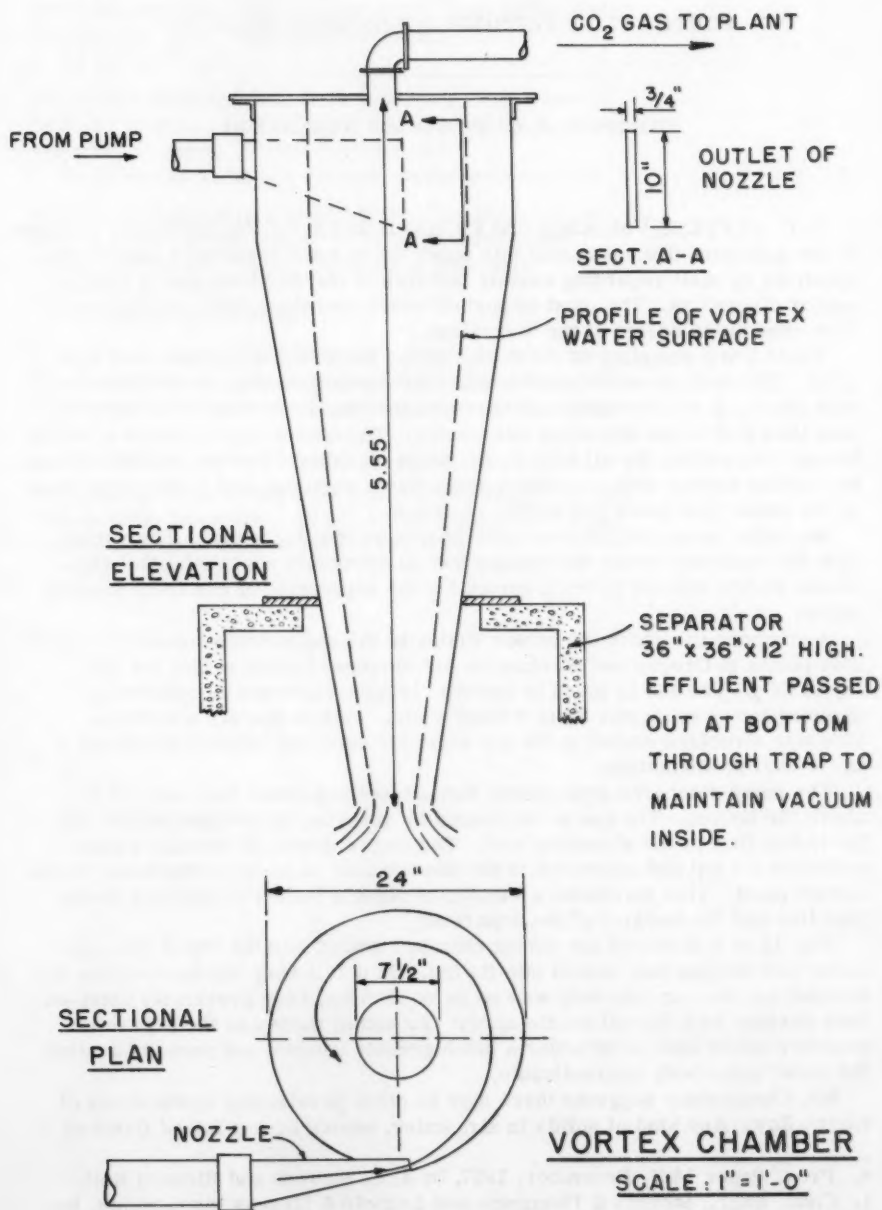


Fig. 12

different densities are susceptible of separation by vortices. There are many such examples already in successful use.

Mr. Posey's illuminating discussion and particularly his Fig. A is very interesting. However he complains of our "unfortunate choice of variable" which makes it "difficult or impossible" to make a comparison of the quantitative results of the two investigations."

In Mr. Hsu's thesis (10) the "variable" used is the tangent of the angle of incidence to the vortex wherein values range between zero and infinity. The vortex number Eq. (27) and following, is a finite dimensionless parameter whose value lies between zero and π .

Mr. Posey states "apparently it is necessary to determine the water surface profile . . . and use the theoretical equation for the water surface hyperbola to determine the vortex number. The designer who wishes to use the author's data . . . will be hard put to estimate the value of the vortex number." Not at all. It is really quite simple.

For every Wisconsin laboratory experiment two important quantities were observed: H the static head on the center of the orifice and the drop-down of the water surface y at a point on the profile for $x = D$ (p. 1461-7). This value of y because of its importance and in order to avoid confusion, has been designated as h herein. The ratio h/H then becomes an important variable for any symmetrical-free flow water vortex. From (29) it is obvious that for $x = D$ the vortex number is

$$\underline{V} = 2 \pi \sqrt{h/H} \quad (32)$$

Also when $x = D/2$ the drop-down y at the edge of the orifice (Fig. 13) = H , $\underline{V} = \pi$, C and consequently Q_x = zero—purely a hypothetical condition.

Furthermore the actual value of h/H cannot exceed .25 because again $\underline{V} = \pi$.

Fig. 14 gives at a glance the essential characteristics of a symmetrical free-flow water vortex. In (a) the ratio h/H is the independent variable from which the vortex number \underline{V} is read on the lower scale and the discharge coefficient C on the left.

In (b) the theoretical flow q , for an orifice 1 foot in diameter is given vs H , the static head on the center of the orifice for which the discharge coefficient is 1.00. The corresponding flow through any other diameter D_x is given by

$$Q_x = q D_x^2 \quad (33)$$

for the same head and discharge coefficient.

The flow for a different diameter and head is given by

$$Q'_x = q D_x^2 \sqrt{H_x/H} \quad (34)$$

and for a different diameter, head and discharge coefficient we have

$$Q''_x = q D_x^2 C_x \sqrt{H_x/H} \quad (35)$$

Examples of the use of Fig. 14 follow:

	h	H	h/H	\underline{V}	C	q	Cq	D_x	C_x	H_x	Q_x
(1)	.052	4.00	.130	2.25	.18	12.5	2.25	1.75	--	--	38.2
(2)	.040	2.50	.016	.80	.52	10.0	5.20	3.00	--	1.25	63.6
(3)	1.00	5.00	.200	2.81	.075	14.2	.99	.667	.10	4.2	.040

The theoretical flow through a 1-foot orifice (21) is

$$q = \frac{\pi}{4} \sqrt{2gH} \quad (36)$$

also the actual flow for a different diameter becomes

$$Q = \frac{\pi}{4} D^2 C \sqrt{2gH} \quad (37)$$

Combining (36) and (37) we obtain

$$CD^2 = Q/q \quad (38)$$

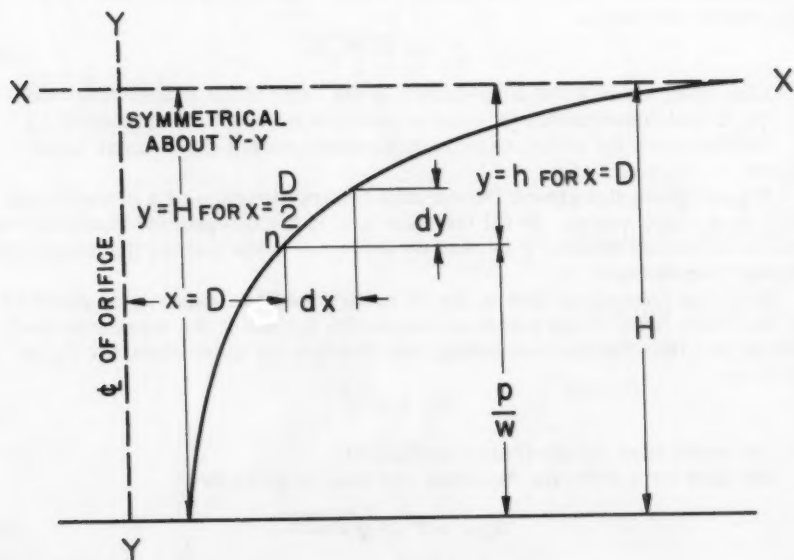
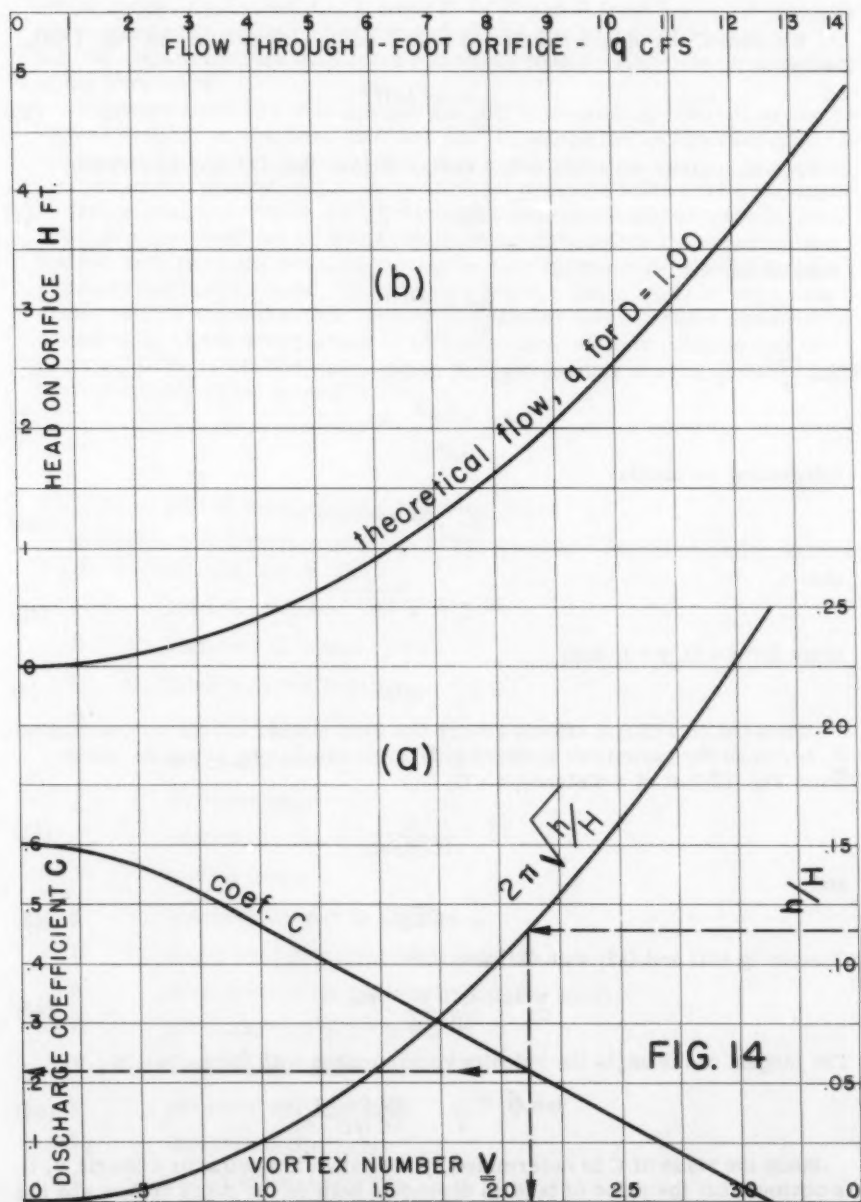


FIGURE 13

FREE VORTEX



We can now choose D and calculate C since the right hand member is known.

Knowing C the vortex number is read from the lower scale of Fig. 14(a), wherein

$$\frac{h}{H} = \frac{v^2}{4\pi^2} \quad (39)$$

from which other elements of the vortex follow. Eq. (1) may be written

$$\frac{dp}{w} = \frac{u^2}{g} \frac{dr}{r} \quad (1)$$

Substitute (2)

$$\frac{dp}{w} = \frac{K^2}{g} \frac{dr}{r^3}$$

but $\frac{dp}{w} = -dy$ and $r = x$, from Fig. 13, hence

$$-dy = \frac{K^2}{gx^3} dx$$

Integrating we obtain

$$y = \frac{K^2}{2gx^2} \text{ as verified in} \quad (28)$$

also

$$K = D \sqrt{2gh} \quad (40)$$

since for $x = D$, $y = h$ also

$$\Gamma = 2\pi K \quad (4)$$

When the centrifugal effects govern the fluid motion and the vortex number, V , becomes the parameter governing dynamic similarity, it can be shown from Fig. 13 that at a distance $x = D$,

$$v = \frac{Q}{\pi D(H-h)} \quad (41)$$

and

$$u = \sqrt{2gh} \quad (42)$$

Combining (41) and (42) with (21) and (29)

$$\frac{V}{\pi} = \frac{C\pi D}{4(H-h)} \tan \theta \quad (43)$$

The tangent of the angle the velocity vector makes with the radius is

$$\tan \theta = \frac{u}{v} = \frac{4V(H-h)}{C\pi D} \quad (44)$$

Since the value of C is determined by the dynamic similarity criteria V , it is obvious that the value of $\tan \theta$ is dependent both on the depth of flow and the orifice diameter. A set of curves similar to Mr. Posey's Fig. A could therefore be drawn for each combination of these terms. In the Iowa tests evidently a single orifice (4") and a nearly constant head of about 2 feet were used.

The curves of V vs C in the Wisconsin tests, however, are valid for the entire range of the tests, i.e. D from 2" to 8" and H from 0.1 to 2.7 feet. Dynamic similarity would indicate therefore that the curves of Figs. 6 and 14 may be used for orifice diameters and heads considerable outside the values of the Iowa tests.

It appears therefore that whether we deal with existing vortices or the design of vortices no one need "be hard put" to determine all the essential characteristics of symmetrical free flow water vortices.

It should be pointed out, however, that all previous tests have been made in orifice chambers which were cylindrical and concentric with the orifice. Many problems will not fit these conditions and therefore the experimental tests at both Iowa and Wisconsin can give only approximate results for non-symmetrical installations. Experiments are now being made by the junior author to determine the effect of orifice chamber irregularities and orifice eccentricity on the flow pattern of vortices. Recent tests indicate that departures from symmetry can produce quite anomalous results compared with those available at the present time.

Errata

1 - Page 1461-2 substitute the following table:

Symbols—The following conform to the American Standard Letter symbols for Hydraulics ASA Z10.2 1942.

A	area of orifice
B	diameter of boundary ring
C	discharge coefficient
D	diameter of orifice
<u>E</u>	Euler number
<u>F</u>	Froude number
F_c	centrifugal force
F_i	inertia force
g	acceleration due to gravity
H	static head on center of orifice
h	drop down to the vortex surface for $x = D$
K	a constant vorticity factor
K_1, K_2	profile constants
p	pressure per unit area
Q_t	theoretical discharge
Q	actual discharge = CQ_t
q	theoretical discharge through 1-foot orifice
<u>R</u>	Reynolds number

r	radius of vortex profile from center of orifice
u	tangential velocity vector
v	radial velocity vector
V	Velocity vector-resultant of u and v
\underline{V}	vortex number
w	specific weight
x, y	coordinates of a point on the vortex surface also x is a subscript denoting a different diameter, discharge, head coefficient, etc.
Y	vertical spacing of boundaries in two dimensional flow
Γ	circulation
ρ	mass density
μ	dynamic viscosity
θ	the angle the velocity vector makes with the radius

- 2 - Fig. 2, 3, 4, 5, and 6 in the formula at the bottom of each figure change V to \underline{V}
- 3 - Page 1461-10 add the reference (see also SA 3 June 1958 p 1688-12)
King Handbook of Hydraulics 4th ed p 3-34
- 4 - Fig. 6 bottom scale change 1.4 to 1.2

MEDIA CHARACTERISTICS IN WATER FILTRATION^a

Closure by Gaurchandra Ghosh

GAURCHANDRA GHOSH.¹—The writer wishes to thank Mr. Hudson for his discussion and for pointing out some of the important observations.

The writer has studied the question of "depth factor" very much more thoroughly than it was possible to discuss in the original paper. Some of the main points on this question are discussed below.

1. Stratification of the bed due to non-uniformity of the particles.

As pointed out by Mr. Hudson, there is likely to be some stratification in a back-washed bed. The media used in the experiments were fairly uniform and were sieved in a machine sieve. Assuming that all the fine particles stratified at the top portion of the filter and the coarser material at the bottom, the size of the fine particles at the top would correspond to the lower sieve size and that of the coarse particles at the bottom to the upper sieve size. From the sieve sizes for these extreme cases, can be calculated the theoretical losses of head per unit length (dh/dl) for the top and bottom parts of the bed for particular velocities. It has been observed that the calculated difference in dh/dl between the top and bottom parts of the bed attributable to stratification of the bed was very much less than the actual difference in dh/dl observed in the experiments. As an example, taking the case of glass ballotini No. 5, sieve range 0.0853 cm. to 0.0699 cm., and a rate of 1 g.p.m. per sq. ft. of filter area, the calculated theoretical difference in dh/dl between the top and bottom parts, due to non-uniformity of the particles, will be 0.07; whereas in the actual experimental results this difference is found to be 0.20 or about three times the theoretical value. The picture is similar in all the other cases. The major part of the difference in the rate of head loss between the top and the bottom of the bed must therefore be due to factors other than stratification resulting from the non-uniformity of the particles.

2. The variation in dh/dl might be due to variations in the packing of the bed.

It is likely that when the supply of wash water was stopped, after back washing, the material in the bed might pack differently in the lower portions due to the accumulating weight of the upper layers. In any case, it is the bottom layers which would pack more densely than the upper layers, and this should lead to a higher rate of head loss towards the bottom of the filter, rather than the reverse effects observed in the experiments under review. The phenomenon can not therefore be explained as being due to such differences in the voidage.

a. Proc. Paper 1533, February, 1958, by Gaurchandra Ghosh.

1. Calcutta, India.

3. Liberation of dissolved gases from the liquid as it moves down the pressure gradient.

The separation of dissolved gases from the liquid as it flows down the pressure gradient, and the retention in the bed of the bubbles so formed, may reduce the space available for flow through the pore channels.⁽¹⁾ This liberation of dissolved gases would have a cumulative dynamic effect, although operative only in the presence of a pressure gradient. Meyerott and Morgenau (1945) studied the flow of distilled water through cracks formed by two adjustable glass plates, and found that the flow decreased with time.⁽²⁾ Actually, it was found to be a volume effect rather than a time effect as when the liquid was stagnant, time had no effect. They concluded that the retardation of flow was due to the formation of small air bubbles on fractures or minute irregularities in the surface bounding the flow.

The liberation of dissolved gases may affect the flow differently at different depths and cause a variation in the rate of head loss. According to Henry's law,⁽³⁾ the mass of gas dissolved by a given volume of liquid is directly proportional to the partial pressure of the gas in contact with the liquid. Taking the worst possible case when the liquid before entry to the bed is assumed to be saturated with dissolved gases, then gas will be liberated if and when the pressure falls below the initial value. The pressure at the surface of the media just at the point of entry to the bed is equal to the constant head of water over the filter bed. The pressure at any depth = constant head of water above the top surface of the media + the depth of the media - the loss of head due to friction. When the frictional loss of head at any depth becomes greater than the depth of the media at that point, the net head at that level will fall below the constant head at entry to the bed, and hence in such a case there is likely to be liberation of dissolved gases owing to reduction of pressure below the initial saturation level. Now let us examine the curves for loss of head with clear water against depth.

It is found that out of the 30 cases of flow considered, only in the following three cases can there be any liberation of dissolved gases owing to the reduction of pressure below the head at entry to the bed.

Ballotini No. 8	2.5 g.p.m.; and 3 g.p.m.
Sand 30 - 36	. . . 3 g.p.m.

In the other 27 cases there is not likely to be any liberation of dissolved gases as the pressure never goes down below the initial head at entry to the bed.

Now let us examine the three cases where liberation of gases is a possibility. In these three cases, the loss of head at any depth is greater than the depth of the media, being greatest towards the bottom of the bed. The volume of liberated gases, as per Henry's law, will therefore be more towards the bottom than towards the top. It is not definitely known how these air bubbles actually affect the flow. According to Rose⁽¹⁾ they probably reduce the available flow space and should therefore increase the resistance. It is also not known how the relative size of the individual bubbles affects the resistance; but taking a general view of the picture as a whole, it is most likely that a larger volume of liberated gases would produce a higher resistance than a smaller volume of separated gases. It is therefore more likely that the liberated gases, which remain entrapped within the bed, in the three cases under review, should produce a higher rate of head loss towards the bottom

compared to the top, which is however the reverse of the experimental findings.

No liberation of gas was observed at any time during the experiments, although it is not unlikely that they escaped notice. However, if the liberated gases have a cumulative effect, then the pressure readings as indicated by the manometer tubes would have changed with time. The manometer readings after only a few minutes necessary to adjust themselves to changed rates of flow (when the rate of flow was changed), remained quite steady. Steady conditions were reached within a few minutes although the actual readings were noted after waiting for some time to see if there was any variation. To see if time had any effect, an experiment was run with clear water (using glass ballotini No. 8, and a constant rate of flow of 2 g.p.m.) for six hours, but no change was observed in the manometer readings.

It is therefore, not likely that the depth factor is due to the liberation of dissolved gases.

4. Electro-kinetic Effects.

Water, even in its purest state, dissociates to a limited extent, liberating a small proportion of hydrogen ions and hydroxyl ions. When it flows through a porous mass, an electric double layer is formed at the solid liquid boundary where ions of one kind are adsorbed and an excess of the opposite ions arranged in a diffuse layer are left in solution.⁽⁴⁾ To start with, the fluid motion in the double layer is without restraint, but because of the removal of a portion of the ions in the double layer during flow, a "streaming potential" is set up between the up-stream and down-stream ends of the porous mass. Ions adjacent to the solid surface of particles begin to move up-stream, and as more and more of the excess ions of the layer are removed, the electro-osmotic counter-flow increases. The energy necessary to maintain the potential difference must come from the applied pressure difference across the bed, and this will affect the rate of flow. It may take quite a long time (may be 15 to 24 hours as found by Ruth,⁽⁵⁾ for equilibrium conditions to be reached when sufficient streaming potential is built up to transport ions electro-osmotically upstream at the same rate as they are swept from the inner portion of the double layer by the liquid flow. In a porous mass of some depth where the pores may be of different size, considerable internal cyclic flow may also take place. Rose⁽¹⁾ has described the phenomenon in a simple way, but he points out that these electro-kinetic effects do not appear to be completely understood. The reduced flow rates observed by some workers may be qualitatively explained as being due to this so-called "electro-viscous effect" although a quantitative assessment of this effect in the case of flow through porous media is still lacking.⁽⁴⁾ In what way these effects are likely to affect flow conditions at the top and bottom of a filter bed, is difficult to forecast. According to Van-de-Vloed⁽⁶⁾ the surface of clean sand is negatively charged, and hence when the liquid enters the bed, the positively charged hydrogen ions are likely to be attracted by the media, leaving the hydroxyl ions to flow down. The liquid will reach the bottom of the bed freed of the positively charged ions and hence there should not be any ionic attraction between the liquid and the media towards the bottom. The attractive forces towards the top of the bed may exert some additional resistance to the flow of the liquid compared to the bottom. The phenomenon, however, requires much more intensive research before definite conclusions can be arrived at.

Various workers have suggested the existence of end effects. Instead of restricting the phenomena to end effects, the author prefers to qualify them by the term 'Depth Factor' and symbolically by df , so as to include all possible causes which may contribute to this effect.

Let us consider the stream line motion above the filter as a stream line motion in a pipe. When the fluid strikes the surface area of the filter, it meets with innumerable obstructions of area 'a' which represents the cross-sectional area of the tube less the cross-sectional area of the voids. Beyond the first line of obstruction the flow does not resume normal conditions, but meets with a battery of further obstructions. The flow through the filter may be looked upon as proceeding along zig-zag lines with sudden enlargements and contractions, till a state of equilibrium is reached. The maximum effect is at the entrance to the media.

At this point let us recall Froude's experiments⁽⁷⁾ on the frictional resistance of surfaces moving in water, as published in the British Association Reports of 1872-1874. Wooden boards of various lengths (varying from 2 ft. to 50 ft.) were towed end-wise, the forces required to tow the boards being measured. One of Froude's conclusions was that the frictional resistance per square foot of surface decreased as the length of the board increased. The explanation for this conclusion was that the relative velocity between the board and water was greater at the front edge. The water was at rest when cut by the front edge, but once the front edge was passed it was dragged along with the board. A bed of filtering media may be imagined to be sectioned into a number of zig-zag boards of irregular shape and configuration. Instead of the fluid passing through the bed of the media, we may imagine the fluid to be at rest, and the laminar boards formed by the media as being dragged upwards at the same relative velocity with which the fluid filters through the media. The relative conditions in both the cases are the same. Even though the analogy is not strictly correct, it suggests that the resistance offered by the short lengths of boards which correspond to the upper portion of the media may be greater than that towards the bottom.

It is now evident that there should be a depth-factor in the laws of flow of fluids through a porous medium, as obtained in the present experiments. The detection of this phenomenon is perhaps due to the particular attention given in studying the conditions in the first few inches of the bed. It is the first few inches (mostly the first three inches) of the filter which most exhibit this effect. As it is a very common belief in waterworks practice that most of the filtration is effected in the top portion of a filter, the experiments were planned to give a greater attention to this portion. The first tapping was only half an inch below the top surface of the media, the next interval being 1" and below that 1-1/2".

The discussor claims that the end effects (designated as 'Depth Factor') whose existence had been suggested by many investigators, have been experimentally discovered. The possible reasons for this phenomenon have been discussed, but no definite answer can be given.

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CHAPTER I

The first part of the book is devoted to a general survey of the subject. It begins with a definition of the term "philosophy" and a discussion of its history. The author then proceeds to a discussion of the various branches of philosophy, including metaphysics, epistemology, ethics, and political philosophy. He then discusses the relationship between philosophy and science, and the role of philosophy in the development of human thought. The book concludes with a discussion of the future of philosophy and the challenges it faces in the modern world.

SEWAGE DISPOSAL IN SANTA MONICA BAY, CALIFORNIA^a

Closure by C. G. Gunnerson

C. G. GUNNERSON,¹ A. M. ASCE.—It is a pleasure to acknowledge the discussion by Messrs. Lawrance and Miller covering additional details of the bacteriological studies. They point out that the rate of reduction of coliforms is lower in subsurface waters. This is reasonable since some of the factors in the mortality of the bacteria, particularly sunlight, are more effective at the surface. The decreasing rate of reduction (or increasing persistence) continues after the solids have been deposited on the bottom where dilution and sedimentation are no longer operative, and mortality is significantly different. Rittenberg, et al,⁽²⁶⁾ have recently pointed out that the coliform populations per unit area on the bottom are greater than those contained in the overlying water at any one time, and that, "the coliforms must survive for a sufficiently long period of time in the sediments to allow large populations to be built up by deposition . . ." As a result, bottom populations measured in tens of thousands per square centimeter may be found near the Orange County outfall where the overlying waters contain less than 10 coliforms per milliliter.

It is possible to make a first approximation of the survival time in the sediments by considering the total daily discharge of coliforms and that portion which settle with the solids; the rate of solids accretion assuming general similarity with the Hyperion sludge studies made by Brooks;⁽²⁷⁾ the general ocean current pattern; and the steady-state requirements for maintaining the observed bottom coliform populations assuming, as did Rittenberg, no multiplication in the sediments. Such an analysis suggests a T-90 in the sediments around the Orange County outfall measured in months.

Mr. Barr suggests that further work on the mechanics of effluent dilution in sea water is desirable. The need for such additional experimental and analytical study is apparent to anyone who is concerned with waste discharges into any body of water. It is recognized that the terminology employed to describe dilution processes at Hyperion is imperfect; it simply calls attention to the observed dilutions in time and space which seem to require more than one diffusion phenomenon. Additional field work which is under way will undoubtedly refine the data presented earlier, and may ultimately permit a rigorous analysis.

In any event, the major objective in studying dilution of Hyperion effluent is to evaluate the bacterial decline rates, and the effect of dilution has been calculated. Variation of the calculated dilution effect within any reasonable

a. Proc. Paper 1534, February, 1958, by C. G. Gunnerson.

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limits will not change the primary conclusion that sedimentation is always important, and may be the predominating factor, in reduction of coliform populations in surface waters.

The available data do not permit a complete analysis of the effect of sea state upon dilution. The observations upon which the bacteriological studies were based required suspension of effluent chlorination. Such interruptions were of necessity, for public health reasons, held to an absolute minimum. However, the sea state varied from calm to a heavy chop for the various series of tests, and no significant difference in the behavior of the effluent field was found. This is in good agreement with observations of the chlorinated effluent field which have been made weekly since July, 1956. These indicate that the prevailing current controls the configuration of the field, and that variations in surface wave conditions have a negligible effect.

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SED RESEARCH REPORT NO. 19
SEWAGE TREATMENT BY LAGOONS^a

Discussion by Herbert Moore

HERBERT MOORE,¹ M. ASCE.—Lagoons offer an economical way of providing sewerage service pending development of suburban areas.

As a temporary expedient to allow time for the municipality to determine upon the best over all sewerage plan, a sewage lagoon was constructed in 1955 by a subdivider in Milwaukee County, Wisconsin. The 74 house subdivision located 1/2 mile north of the Milwaukee-Racine County line, and 3/4 mile from Lake Michigan has thus been served satisfactorily for three years under the supervision of the writer serving in behalf of the City of Oak Creek. Located 300 feet from the nearest residence, and screened by trees and green-foliage-covered earth embankments, and fenced for protection, a 1/3 acre, three foot deep lagoon takes care of a tributary population of 250, which is at a rated "loading" of 750 persons per acre. No odor nuisance has been reported by neighbors. The daily flow is about 20,000 gallons.

A stereotyped sewage disposal plant to cost the purchasers of the homes \$45,000. was proposed by the subdivider and rejected by the then Town of Oak Creek officials because it appeared to be too costly for what would doubtless be a temporary facility and because it seemed to be a poor location which would subject neighbors to nuisance conditions.

During this past summer a 55 gpm electric pump, actuated by float control, was installed for the two-fold purpose of lowering the lagoon level to flush solids that tended to plug the incoming sewer and threatened basement flooding; and to secure thru intermittent discharge, better evaporation and disposal of effluent. Also the pump set up mixing currents in the lagoon which were beneficial. In dry weather all effluent disappears by evaporation or by soil absorption in an 8" subsurface tile line.

a. Proc. Paper 1678, June, 1958, by the Sanitary Engineering Research Committee, Sewage Treatment Section.

1. Cons. Engr., Maxon and Moore, Cons. Engrs., Milwaukee, Wis.

1. The first part of the paper discusses the importance of the study of the history of the United States. It is argued that a knowledge of the past is essential for a full understanding of the present and for the development of a sound policy for the future. The author points out that the history of the United States is a complex and varied one, and that it is necessary to study it from many different angles in order to gain a complete picture of it.

2. The second part of the paper discusses the role of the government in the development of the United States. It is argued that the government has played a crucial role in the development of the country, and that it is necessary for the government to continue to play this role in the future. The author points out that the government has been responsible for the establishment of the Constitution, the creation of the federal government, and the development of the country's infrastructure.

3. The third part of the paper discusses the role of the individual in the development of the United States. It is argued that the individual has played a crucial role in the development of the country, and that it is necessary for the individual to continue to play this role in the future. The author points out that the individual has been responsible for the establishment of the Constitution, the creation of the federal government, and the development of the country's infrastructure.

4. The fourth part of the paper discusses the role of the future in the development of the United States. It is argued that the future is a crucial part of the development of the country, and that it is necessary for the future to continue to play this role in the future. The author points out that the future has been responsible for the establishment of the Constitution, the creation of the federal government, and the development of the country's infrastructure.

5. The fifth part of the paper discusses the role of the past in the development of the United States. It is argued that the past is a crucial part of the development of the country, and that it is necessary for the past to continue to play this role in the future. The author points out that the past has been responsible for the establishment of the Constitution, the creation of the federal government, and the development of the country's infrastructure.

FORCED CIRCULATION OF LARGE BODIES OF WATER^a

Discussion by C. H. J. Hull

C. H. J. HULL,¹ A. M. ASCE.—Mr. Riddick has presented valuable data on a method of artificially turning over a stratified lake or reservoir by injection of air well below the surface. It should be noted that this method is not new in theory or in practice; it has been used or suggested for similar purposes for many years.

The air-lift principle is probably most familiar to sanitary engineers in connection with the activated sludge process. An aerating cone, which performs in a manner quite similar to Riddick's device, lifting sewage vertically and forcing it out horizontally, was described in 1954.⁽¹⁾ This system was credited with causing rapid turnover and absorption of atmospheric oxygen. Mr. Riddick's paper, like the earlier one mentioned above, also credits atmospheric oxygenation at the surface with most of the D. O. gain. As discussed later, the writer is not convinced that photosynthesis did not add a significant part of the oxygen increase observed in the Ossining experiment.

The author presents some very interesting data on the prevention of freezing by vertical mixing of the thermally stratified water. This method has been used earlier at various locations for this purpose. In 1954, Bier^(2,3) presented two articles on the theory, design, and installation of a compressed air de-icing system for use at dams, power plants, pumping plants, and other installations.

Mr. Riddick states that "... it seems possible that ice formation could be prevented in shipping lanes by appropriate aeration devices to cause an upwelling of warmer water below." It is interesting to note that the air-lift principle has been used for this purpose. In a ferry slip on the St. Lawrence River, compressed air released from a perforated pipe near the bottom lifted the slightly warmer deep water to the surface, melting existing ice and preventing its formation.⁽⁴⁾ In 1955, Small⁽⁵⁾ discussed the possibility of forced vertical circulation to prevent ice formation in the Gulf of St. Lawrence.

The technique of lifting deep water with compressed air was proposed for a different purpose by Streiff⁽⁶⁾ in 1955. In this case, the air would also cause an artificial turnover of a stratified reservoir, but the aim was temperature reduction at the surface to reduce evaporation rather than any of the benefits mentioned by Mr. Riddick. However, Streiff's scheme, in accomplishing his purpose, would automatically accomplish most of those suggested by Mr. Riddick.

a. Proc. Paper 1703, July, 1958, by Thomas M. Riddick.

1. Research Associate, Dept. of San. Eng. and Water Resources, The Johns Hopkins Univ., Baltimore, Md.

As early as 1953, the air-lift method was used to promote vertical circulation in water-supply reservoirs. In tests in two reservoirs in Los Angeles, reported by Derby, (7) an attempt was made to lift oxygen-deficient bottom water by air entrainment. According to Derby, "Water was moved in large volumes but it tended to fall back to the deep zone. Insufficient horizontal circulation prevented complete success, but the thermocline was definitely lowered in both reservoirs." This description is evidence of the value of the deflector plates on the float used by Mr. Riddick. Apparently these deflectors were responsible for the complete success in the later test, compared with only partial success in Derby's experiments.

As mentioned previously, the author credits most of the observed D.O. pickup to atmospheric aeration across the air-water interface. Such a conclusion is not warranted unless evidence was obtained showing that photosynthetic oxygenation by algae was insignificant. No mention was made of any attempt to measure photosynthetic oxygen production rates in Ossining Reservoir. Such measurements would have been a most worthwhile addition to Mr. Riddick's experiment.

In the writer's opinion, photosynthesis probably did add a significant portion of the observed D.O. increase. Years ago, this writer measured photosynthetic oxygenation in Baltimore Harbor(8) and found it to be quite important in the overall oxygen balance. Using the light-and-dark-bottle technique, the writer found an average photosynthetic production rate of about 24 pounds of oxygen per acre per day. One series of experiments in Baltimore Harbor is of special significance in relation to the upwelling of deep water in Ossining Reservoir. In these particular tests, water was collected from well below the normal maximum depth of measurable photosynthesis and exposed in light and dark bottles at various depths in the euphotic zone. These tests showed that the deep water in the stratified harbor had all the ingredients necessary for photosynthesis except light. Bringing the water into the normal euphotic zone (about 11 feet deep in Baltimore Harbor) corrected this deficiency and significant quantities of oxygen were produced.

Observations elsewhere by the writer and by many other investigators(9,10,11,12,13,14) indicate that photosynthetic oxygenation is the rule rather than the exception in surface waters throughout the United States. Mr. Riddick himself has listed a substantial variety of algae found in Ossining Reservoir. The fact that algae are present is proof in itself that photosynthesis does occur. It therefore appears likely that some of the oxygen gain—and the CO₂ reduction—accompanying the forced circulation in Ossining Reservoir can be attributed to photosynthesis, and not wholly to atmospheric exchange.

The author states that reservoirs in the United States undergo two overturns yearly. It should be pointed out that reservoirs in the southern part of the United States normally do not get cold enough to form winter stratification, but remain mixed from the fall overturn until stratification forms in the spring. These reservoirs therefore have no spring overturn.

Probably the most significant finding reported by the author is the low energy requirement for inducing vertical circulation in stratified water. Although it can be shown that the theoretical energy requirements in this scheme are quite low, no data were previously available to the writer on the overall efficiency of applying the energy. Mr. Riddick's reported success with only eight horsepower indicates a reasonably high efficiency for forced circulation with compressed air. This information is a valuable addition to the earlier

literature on this method. The low energy requirement cited should encourage further experimentation in this technique aimed at improving water quality, reducing evaporation, and preventing freezing.

The author has stated that the overall aeration process—for floating or stationary types—is being patented. The writer has called attention to a list of references in the published literature indicating rather extensive previous use of the technique for various purposes. Undoubtedly the list is not complete. In view of this wide knowledge and application of the method, it appears pertinent to ask if the process is patentable.

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1870
The first of the year was a very dry one, and the crops were much injured by the drought. The weather was very hot, and the crops were much injured by the drought. The weather was very hot, and the crops were much injured by the drought. The weather was very hot, and the crops were much injured by the drought.

The second of the year was a very wet one, and the crops were much injured by the rain. The weather was very cold, and the crops were much injured by the rain. The weather was very cold, and the crops were much injured by the rain. The weather was very cold, and the crops were much injured by the rain.

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The fifth of the year was a very dry one, and the crops were much injured by the drought. The weather was very hot, and the crops were much injured by the drought. The weather was very hot, and the crops were much injured by the drought. The weather was very hot, and the crops were much injured by the drought.

DESIGN DETAILS FOR INDIVIDUAL SEWAGE DISPOSAL SYSTEMS^a

Discussion by Louis Finaly

LOUIS FINALY.¹—As a reader in a foreign land, the writer is concerned with the lack of clarity in some of the expressions used by the author. The terms of special concern are "Perk-tester" on p. 3, "mere convenience" p. 6, "lids" and "hatches" on p. 9, "fouling" effect of surface drainage water to septic tanks, p. 11. Also, the differences, if any, between "seepage" and "leaching" pit, disposal "field" and "bed" should be explained.

The percolation test described by Mr. Martin does not appear to be a correct one. The author does not give the height of the water column that should be produced in the test hole. Also, should this height be measured from the bottom of the hole or from the area in which leaching is taking place or from the level from which the fall of the water is measured. Also, it should be noted that, however measured, this height is not a linear function with time. Thus, the computed time for a 1 in. fall (which is obtained by dividing the time for a 6-in. drop by 6) may not be correct for the first 1-in. fall or the sixth 1-in. fall.

It seems as though the footnote on p. 7 is in error as it is contradictory to items A and C in Table II.

In the estimate, on p. 8 and 9, of the standardized cinder-black septic tanks, there seems to have been omitted that part of the tank which is between the T.W.L. and the cover of the tank. Although this is a variable which depends on the depth of the house sewer, it should be included in the estimate.

a. Proc. Paper 1715, July, 1958, by Harrison Martin.

1. Dipl.-Ing., Budapest, Hungary.

CONTROLLED SUBMERGENCE OF PITTSBURGH'S DEEP SEWERS^a

Discussion by Edwin B. Cobb and Allen J. Burdoin

EDWIN B. COBB,¹ M. ASCE and ALLEN J. BURDOIN,²—Some large intercepting sewer systems have been operated for extended periods at high sewage levels to save on power costs, but the Pittsburgh system is the first system known to the writers to be designed to operate submerged throughout the main portion of the system, including all the larger diameter pipe. The advantages of designing for controlled submergence have been ably presented by Mr. Laboon. Substantial economies in the cost of construction have been realized, since the interceptor sizes are undoubtedly smaller than in a normal design based on free surface flow, so that the total annual savings to the users will exceed the estimated \$135,000 per year saving in power costs.

By careful selection of pipe sizes, the works have been designed to keep to a minimum the deposition of solids in the interceptor, and the weekly pumping down of the system will doubtless flush out the grit which is deposited. Another advantage of the weekly pumping down of the wet well to obtain free surface flow in the interceptors is the removal of scum and floating solids which collect in the manholes and access shafts during submerged flow. This was not mentioned by Mr. Laboon.

The writers had a part in the design of the pumping station at the Pittsburgh Sewage Treatment Plant, and the writers believe the discussion of controlled submergence would not be complete without some mention of a number of additional factors that had to be considered in the design of the pumping station.

The selection of sewer sizes to maintain minimum velocities of approximately one foot per second at minimum flow when flowing full resulted in a very deep station of unusual design. The pumps are located in an annular dry well surrounding the central wet well which is 40 feet in diameter. The motors are mounted on top of the pumps. The wet well is serviced by a crane revolving on a circular track, and the pumps are serviced by a crane running on an annular track. The electrical control room is located at ground level, approximately 110 feet above the centerline of the pumps. An elevator was installed for access to the pump room, in addition to the usual stairway.

In the normal design, increased flows cause a rise in level in the wet well, and a decreased pumping head where the pumping station is located at the sewage treatment plant as at Pittsburgh. At a decreased head the pump capacity increases, resulting in some degree of self-regulation. When the interceptors operate submerged, an increased flow is still sensed by a rise in the

a. Proc. Paper 1717, July, 1958, by J. F. Laboon.

1. Partner, Metcalf & Eddy, Cons. Engrs., Boston, Mass.

2. Consultant, Metcalf & Eddy, Cons. Engrs., Boston, Mass.

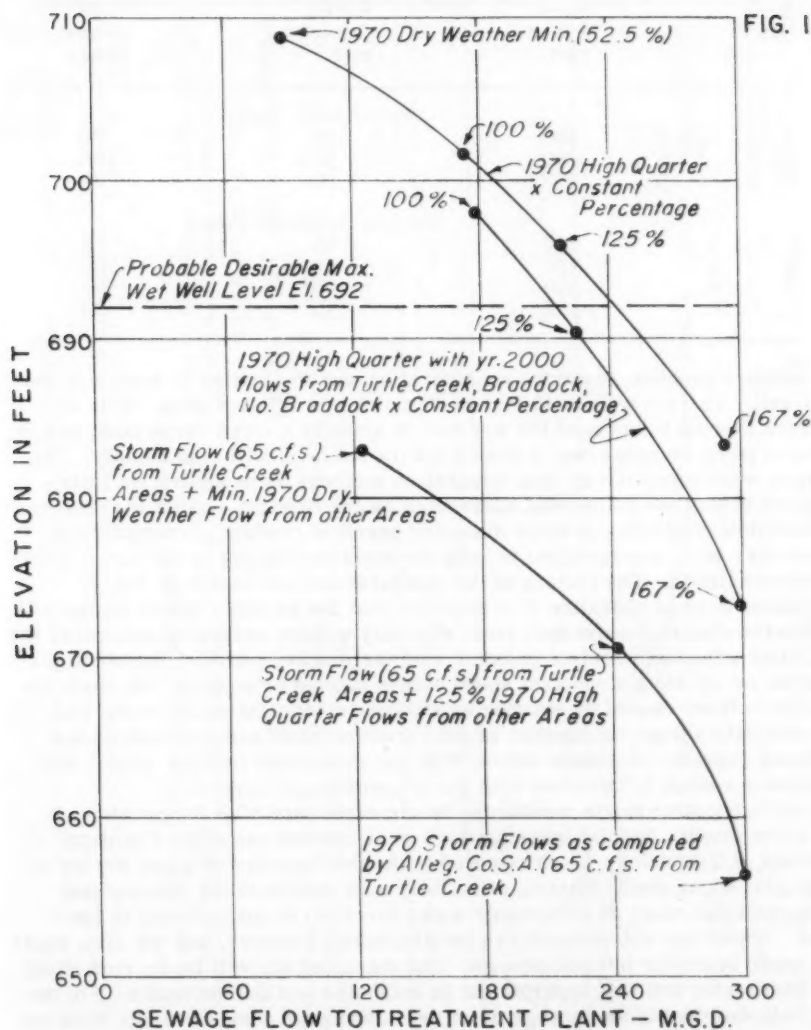
level of the wet well which is accompanied by a greater rise in the level of the sewage at the points in the system where the flow changes from free surface flow to submerged flow. To get the sewage to the wet well without increasing the upstream level, it is necessary to lower the wet well level which reduces the capacity of the pumps.

The computed wet well levels necessary to avoid backing up of the interceptor above design levels under several assumed flow conditions are shown on Fig. 1. The large variation in required pumping head is apparent from the figure. Note that as the flow increases the required pumping head also increases. The situation is similar to that of pumping through a long undersized force main, but with this difference: all the variation is on the suction side of the pumps. Consequently, the pumps had to be set deep down in the ground. The weekly drawdown imposed an additional maximum head requirement of 106 feet, but fortunately some reduction in pump capacity was permissible at this head, since the operation is to be carried on during minimum flow periods. In the normal design of large intercepting sewer systems, the storage in the interceptors is very great, which permits the designer considerable latitude in pump selection. With controlled submergence there is no storage in the interceptor except in the manholes and access shafts and in the upper ends of the system where the sewers are small.

To solve the two problems of practically no storage and wide variation in pumping head economically, a combination of infinitely adjustable variable-speed pumps and two-speed pumps was required. By reference to Fig. 1 it will be noted that the maximum desirable wet well level is El. 692, and that this elevation holds for all 1970 dry weather flows below 240 mgd. This level was determined by the elevation of a number of existing sewers which must be intercepted. All dry weather flow for many years will be pumped with only enough variation in wet well level for operation of the automatic float control switches. One variable-speed unit will operate at all times, and the two-speed units will cut in and out at low speed automatically as required by the flow. The capacity of the variable-speed units has been made slightly greater than the capacity of the two-speed units on low speed to obtain continuous stepless variation in pumping capacity throughout the entire range of dry weather flows.

When storms occur the two-speed pumps will be put on high speed manually to draw the wet well down quickly and maintain it at the elevation necessary to prevent excessive water surface elevations in any part of the system. The control point of the float control device has been made instantly adjustable over a wide range of levels and the variable-speed pump will be kept in operation to stabilize the level at the desired point. If necessary for this purpose, the second variable-speed pump can be placed in operation. By reference to Fig. 1 it will be noted that for the same inflow widely varying levels in the wet well may be required. For example, a local storm in the Turtle Creek area producing a maximum design storm flow of 65 cfs. from that area requires a substantial drawdown of the wet well at inflow rates that could normally be handled at the maximum level. The level telemetering system described by Mr. Laboon is therefore an absolute necessity with this type of system.

Although the pumps have always been referred to as 60-mgd. units, it was realized from the very beginning that their capacity would vary within wide limits. The specified capacity is shown in Table 1.



ALLEGHENY COUNTY SANITARY AUTHORITY
PITTSBURGH, PA.

PITTSBURGH SEWAGE TREATMENT PLANT
SEWAGE PUMPING STATION
REQUIRED WET WELL LEVELS

Table 1. Specified Capacity of Main Pumping Units

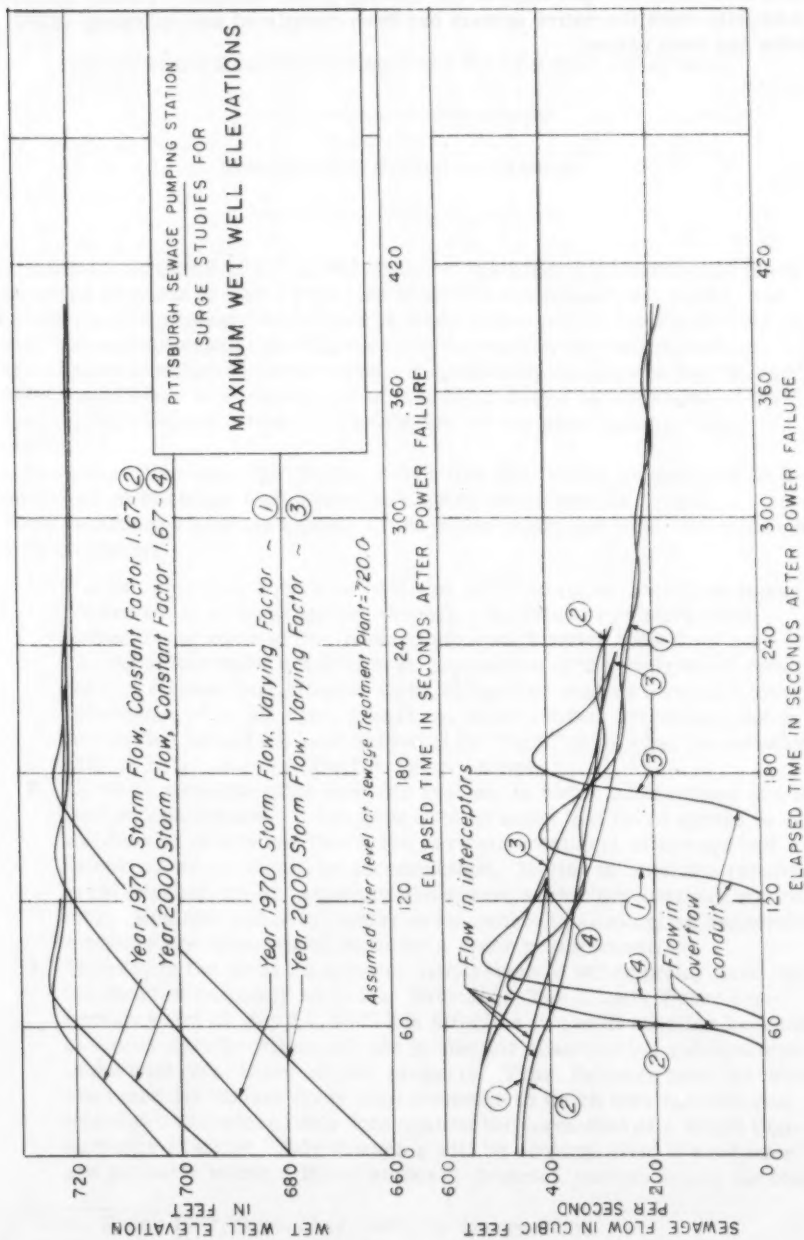
Pump Nos.	Pump Speed, rpm.	Rated Capacity, mgd.	Total Dynamic Head, ft.
Two-Speed Pumps			
2, 3, and 5	400	75	78
2, 3, " 5	400	50+	106
2, 3, " 5	277	50	39
Variable-Speed Pumps			
1 and 4	390	45	76
1 " 4	390	14+	106
1 " 4	390	66± 3	40
1 " 4	312	45	39

Another problem requiring consideration was the matter of surges in the wet well. The wet well is 40 feet in diameter and 118 feet deep. With the sewers flowing submerged the wet well is actually a large surge tank, and in case of pump stoppage due to power failure the level will rise rapidly. The surges were computed by step integration methods using equivalent interceptors having the same total momentum as the existing system for each assumed flow condition. A large diameter overflow conduit, protected by a backwater gate, was installed to keep the maximum height of the surge within desirable limits. The results of the computations are shown on Fig. 2.

During normal operation it is expected that the variable-speed pumps will follow the changes in wet well level smoothly without surges on account of the infinitely adjustable control possible with the magnetic drive. Slight surges may be set up when a constant speed unit is started or stopped, but since the change in level caused by starting or stopping a constant-speed pump will immediately adjust the capacity of the variable-speed pump to match total pumping capacity to sewage inflow, it is not anticipated that the surges will be severe enough to interfere with pump operation or control.

Another matter worth mentioning is one associated with the problem of air entrainment. Special investigations were carried out at the Carnegie Institute of Technology which resulted in the development of a new design of drop inlet which would function effectively with minimum air entrainment throughout the range of interceptor water levels to be encountered in operation. Not all air entrainment can be eliminated, however, and the drop inlets will pump some air into the sewage. The entrained air will be carried along the interceptor and will separate out in manholes and access shafts or in the wet well, but during its passage down the interceptor some of it will dissolve in the sewage. Since the interceptor is under an absolute pressure of about three atmospheres where it enters the wet well, the dissolved air and gases may be three times normal. This should have an advantage in keeping the sewage fresh. However, the sewage will pass directly through the bottom of the wet well into the pump suction without releasing the dissolved gases. The pump discharges are equipped with siphons and vacuum breakers at ground level instead of check valves. A vacuum tank, vacuum pumps, and piping are provided to keep the siphons in operation fully primed automatically. In sizing this equipment it was assumed that the dissolved air and gases in the sewage would amount to three times normal saturation values.

FIG. 2



It is to be hoped that this valuable paper will be followed by additional information on the operation of the system by the Allegheny County Sanitary Authority when the entire system has been completed and operating experience has been gained.

PROPOSED CHANGES IN EASTERN WATER USE POLICIES^a

Discussion by Samuel A. Greeley

SAMUEL A. GREELEY,¹ A. M. ASCE.—This paper illuminates the much discussed problem of water policy as it affects municipalities, states, and the federal government. Reference is made to two major doctrines—that of prior appropriation and the riparian doctrine embodying reasonable use. The paper draws attention to an increasing insufficiency of water in the “humid” eastern states and to the influence of this in causing a re-appraisal of the riparian doctrine and a trend of thought toward the prior appropriation doctrine.

The paper discusses the “Model Water Use Act” under preparation by the University of Michigan Law School and states seven specific points.

As regards the general aspects of the water policy problem, the writer has three comments.

1. The two principal doctrines referred to in the paper should be supplemented by or at least applied through a doctrine of relative need. Reference is made to the indented paragraph under point 3 on page 4. The case described illustrates an application of the doctrine of relative need. I suggest that a water-right, alleged or real as a court might determine, when not used, should not deter another active use, but in so yielding should not lose authority or “right” if or when the relationship or relativeness of the two needs changes.
2. There is a considerable need for realism in water management and in discussions thereof. It has been said by some that there should be no pollution of rivers and that a 100 per cent treatment of sewage and industrial waste should be accomplished. Having in mind the resulting great expenditure by taxpayers and users, such objectives are not realistic. Realism and progressive development to accomplish reasonable economy are essential to successful river management.
3. Thirdly, in the writer’s opinion, discussions of water policy have fallen far short of adequacy as to fair financing. The Illinois Water Conservancy Act of July 11, 1925 has failed as to useful adoption because, to a considerable extent, all the money for construction and operation is derived from taxes on real property. Thus, farmers near the divide are taxed for distant river improvements in which they have no real interest. Therefore, they vote against the formation of a River Conservancy District. Fair financing will be accomplished if each user and property within a River Authority District, contributes to the total

a. Proc. Paper 1777, September, 1958, by Murry Stein.

1. Partner, Greeley and Hansen, Engrs., Chicago, Ill.

annual cost, approximately in proportion to that part of such cost as the individual user or property causes to be made.

It is noted that the application of the foregoing procedure (Item 3) will, in some instances, be complicated. But the use of such a fundamental procedure will, it is believed, receive public and court support because of its fundamental fairness even though complete fairness is not reached.

As regards a Model Water Use Act, it may be stated that the fewer restrictions, the better for the administration. If the administrative body were permitted by the state to be autocratic and were altogether fair in practise, the best management would result.

There is an immediate importance to discussions of changes in eastern water use policies because, as the author states, the resolution of alternates will establish the pattern of water resource development for the next 100 years. In the writer's experience, the pattern of water management cannot be predicted for a long future and therefore model acts should not be so rigid that they cannot be fairly adjusted to presently unforeseen future local and national "relative" needs.

PLANNING THE FUTURE FOR CHICAGO'S WATER SYSTEM^a

Discussion by Charles H. Capen

CHARLES H. CAPEN,¹ M. ASCE.—To most engineers the water problems in the vicinity of the Great Lakes are quite different from those in many other parts of the United States. The present aim in Chicago to plan for the next twenty-five years is probably predicated on the door step availability of a more or less inexhaustible supply. In the New York-New Jersey area the custom that seems to hold sway was well expressed by the late Commissioner Huie of the New York Board of Water Supply who said in effect, "We must raise our sights from a twenty-five year period to one of fifty years." This is because experience has shown that from the inception of a project for a source of water supply, located at considerable distance, to its completion requires often between one and two decades. As a result of this, plans for the last few years in New Jersey have tried to visualize conditions in the year 2,000.

Much has been said in the past regarding the high per capita usage and the incomplete metering in the Chicago area but the figures presented by Mr. DeBerard regarding the effectiveness of inspections and consequent leak reductions leads to the belief that a solid foundation has been laid for justifying the present planning.

The reference to lawn sprinkling, kitchen and laundry appliances and air conditioning is most appropriate. These items have had a far greater impact on peak loads and on per capita usage than is generally acknowledged. The City of Chicago, relying as it does a good deal more on pumping facilities and adequate main capacity than do those cities which have large upland impounding reservoirs, is to be commended on the forward looking program for augmenting its system to meet these peaks. Conversely it may be noted that many of the shortages or lack of water coming from a faucet in numerous communities are caused by insufficient distribution facilities rather than a lack of supply.

Perhaps the most striking part of the program is the rate of 16 cents per thousand gallons. It is remarkable that the expenditures planned can be financed on so low a rate. The feature of an extra charge to outside communities is certainly a step in the direction of good hard common sense.

a. Proc. Paper 1782, September, 1958, by W. W. DeBerard.

1. Chf. Engr. North Jersey Dist., Water Supply Comm., Wanaque, N. J.

FORESTS AND WATER YIELD^a

Discussion by J. C. Stevens

J. C. STEVENS,¹ M. ASCE.—What a revolution in the attitude toward forests regarding the effects on water supplies during the past fifty years! The then official, and by induction, public thinking on this subject is well epitomized by the following excerpts.

"The connection between forests and rivers is like that between father and son. No forests, no rivers." (!) —The Fight for Conservation, by Gifford Pinchot 1909, Page 53.

Among the direful prophecies this one from the Scrap Book of September 1908 wins the blue ribbon. "When our forests are gone, the streams will dry up, the rivers will cease to flow, rain will fall no more and America will be a desert." (!)

These are but two examples of the fallacious propaganda with which this country was flooded at the turn of the century. But there was a cogent reason. Unless it could be shown that forests are essential to navigation, there was no lever by which forest reserves could be created.

The folks back home, propagandized, heckled, badgered and brow beaten into accepting such falsehoods as scientific facts finally convinced Congress who grudgingly created what is now the U. S. Forest Service. Thus, out of false conceptions grew one of our most valuable assets. That Service, now well financed and well administered by a courteous and cooperative personnel has demonstrated that desirable ends sometimes can justify the means.

Among the many beneficial effects of forests claimed by the many protagonists when the sparks were flying and the official bombardment was the heaviest were:

1. Extremes of temperature of air as well as of soil are prevented.
2. The average humidity of the air is increased.
3. The disposition of precipitation is favorably affected.
4. By condensing dew, hoarfrost and ice on their branches, trees add to the precipitation.
5. Forests keep the soil underneath granular and porous for the reception of water.
6. Oxygen and ozone produced by forests increase the purity of the air.
7. Soil conditions of the forests are unfavorable to the production and existence of pathogenic microbes.
8. Forests induce greater uniformity of stream flow than would obtain without them.
9. Forests increase precipitation.

a. Proc. Paper 1848, November, 1958, by Nadavia Bethlamy.

1. Cons. Engr., Stevens and Thompson, also Leupold & Stevens Instruments, Inc., Portland, Ore.

The research done in later years, cited by the author and otherwise, has largely been directed toward proving whether these claims have any facts to support them. The writer believes that there is still some doubt about items 5 and 8. However, there is little doubt but that the others are captious and fallacious.

Two well recognized benefits of forests are (1) to minimize soil erosion and (2) as a perpetual source of timber supplies. The author has named a third—a sort of back handed one, however—viz. the benefit of increased water supply when forests are removed. This phase is most important to the City of Portland. The writer believes that the city's water supply can be materially increased and the virginal forest cover of the Bull Run watershed can, by intelligent management, be converted from what is now a financial liability to a decided asset.

Two additions are offered to the references cited by the author. The one by the writer contains data on 9 long time river records varying from 35 to 78 years with information on the changes in forest cover of the watershed of each where available. For each of them there are given, by 8, 9 or 10 year averages, the precipitation, the run off, total and per inch of precipitation, the minimum and maximum discharge and their ratio—a flow uniformity index. Although this paper is an old one, it still contains food for thought.

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FIELD TEST OF THE MOVEMENT OF RADIOACTIVE CATIONS

Ben B. Ewing,¹ J. M. ASCE

ABSTRACT

The Sanitary Engineering Research Laboratory of the University of California, Berkeley, has been studying the feasibility of underground disposal of radioactive wastes. As part of this project, a synthesized radioactive waste containing Sr⁸⁹ and Cs¹³⁴ was injected into a confined permeable underground formation and its movement traced by radioassay of samples from monitoring wells distributed at various distances from the injection well. The results were correlated with field-scale hydraulic flow tests and a laboratory investigation of the ion-exchange properties of earth material taken from the same formation. The radioactivity pumped from the well during redevelopment was also investigated.

INTRODUCTION

The problem of the disposal of radioactive wastes is to provide a place in which the radioactive decay process may occur without producing unsafe levels of radiation to man and biological systems important to man. It is generally accepted that this may be accomplished either by dilution and dispersal in the environment or by concentration and storage of the waste in a remote or shielded location. Liquid wastes may be particularly troublesome because of activities too great for dilution and volumes too great for storage.

The principal source of high-level liquid radioactive wastes is the processing of spent fuel elements from nuclear reactors. These high-level wastes constitute the bulk of the total radioactivity, but may be produced at only a few fuel-processing plants. Low- and intermediate-level wastes include reactor cooling water and laboratory and hot laundry wastes.

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High-level wastes are presently stored in steel-lined concrete tanks. Evaporation to reduce the volume of storage required may be accomplished by applied heat or by the heat of decay. Storage requires much longer than the life of the tank, so that the total cost may be many times the cost of construction of the necessary tank capacity. Intermediate-level wastes may be stored after concentration by ion exchange or by evaporation. In either event, the treated effluent liquid is generally of low concentration and can be diluted for disposal. Some disposal of these intermediate wastes in ground pits and seepage cribs in upper soil formations has been undertaken for several years, resulting in considerable savings.

Several methods have been proposed for cheaper disposal of high- and intermediate-level wastes and many of these are currently being investigated. There is some possibility of converting the waste to a by-product by recovering economically important isotopes from the fission products in fuel-processing wastes. Removal of the more hazardous isotopes, such as Sr^{90} and Cs^{137} , for use in industry or research or selective disposal of these more hazardous isotopes may simplify disposal of the remaining waste. Pyro-processing, in lieu of solvent extraction of spent fuel elements, would result in a solid waste and reduce the amount of high-level liquid waste. Fixation of radioactive cations on clays has been proposed as a means of concentrating high-level wastes. The ocean has been considered as a possible remote and permanent disposal site because certain ocean depths change their water very slowly. Ground disposal into deep or superficial formations appears to have promise.

At Oak Ridge, pits have been constructed in a shale formation. These serve primarily as storage basins with some concentration of waste by evaporation. The uptake of radioactivity in the soil is secondary. At Hanford, the waste is allowed to seep down through a deep surface formation. The considerable ion-exchange capacity of this formation results in the complete removal of measurable radioactivity before the waste reaches the ground water. This system is made possible by a combination of low rainfall and a deep ground-water table underlying a permeable formation with significant exchange capacity. Investigations of the possibility of injection of the wastes into salt domes, abandoned salt mines or other salt formations are being carried out at the University of Texas. Injection of radioactive wastes into deep underground formations through reverse wells have been considered under two sets of conditions. The first is a static condition in which the waste is injected into a structural basin, and the second is a dynamic condition in which the waste is pumped through a permeable formation in a manner similar to that used for flooding operations in the oil industry. The treated waste would be collected from outlet wells located at some distance from the point of injection. The flooding system was the subject of this investigation.

The capacity of an underground formation for radioactive wastes may be considerable. The pore volume alone may be quite large, inasmuch as the porosity of a formation is commonly ten to twenty per cent. Since the two radioisotopes most critical from the health standpoint, cesium and strontium, are commonly found in the cationic form, the base exchange capacity of the soil formation may contribute very considerably to the total storage capacity. This has been found in the laboratory to be 5 to 1000 times the pore volume.

The petroleum industry has disposed of salt water wastes produced during oil production by injecting the brine back into underground formations at a cost much less than currently required for storage of radioactive wastes in

concrete tanks. The chemical industry has also used this method of disposing of toxic wastes. Due to the additional control required, the cost of injecting radioactive wastes would, of course, be much greater. But, owing to the high cost of tank storage, there may still be a considerable margin. Another advantage is the disposal without preconcentration for large volumes of intermediate-level wastes.

On the other hand, there are many problems incidental to the injection of radioactive wastes. These include the careful exploration of the site, possible pretreatment of the waste to make it compatible with the formation and to remove particulate matter and microorganisms, care in operation of the system to prevent pressure fracturing and clogging due to dispersion of the clay in the formation. Short-circuiting of liquid within the formation due to channelling through fissures would render much of the formation useless for waste treatment. The problem of heat generation from the concentrated radioactivity in the formation could be serious. Because it is highly saline, the connate water forced from the formation during flooding operations may present a disposal problem itself. Finally, the entire system would require careful monitoring to insure protection of water supplies and mineral deposits.

The Sanitary Engineering Research Laboratory of the University of California at Berkeley has studied the general problem of ground disposal of radioactive wastes for the past four years. Most of this work was reported at the Third Nuclear Engineering and Science Congress.⁽¹⁾ These studies have been directed toward theoretical aspects rather than *ad hoc* solutions to immediate engineering problems. The aspects investigated have included the exchange capacity of typical connate-water bearing sands, the competition of strontium with calcium and of calcium with sodium for the exchange sites, and the ion-exchange reaction rates and their effect on the exchange behavior. Later studies on the ion exchange behavior of cesium, the effect of waste composition on the equilibrium, and the effect of length of travel through the formation on the shape of the cation breakthrough curve have since been carried out.⁽²⁾

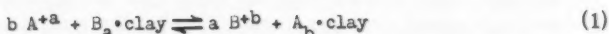
These studies have progressed to a point where a field scale test appeared warranted. The purpose of this field test was to demonstrate that the rate of movement of radiocations in a natural formation can be predicted from laboratory data regarding the ion exchange behavior and a comprehensive knowledge of the hydraulic characteristics of the formation.

Prior to the field test, a sample of the material taken from one of the monitoring wells when drilled was studied in the laboratory to determine its ion exchange capacity and the rate of movement of cesium and strontium as compared with the velocity of the water through a column filled with the same material. A similar waste was then injected into the formation in the field through a reverse well and the rate of movement of the cations was followed by testing samples from monitoring wells distributed at various distances from the injection well. The data collected made possible a comparison of the actual field results with those predicted from the laboratory tests. The cations selected for injection, because of the public health hazard, were cesium and strontium. In order to reduce the hazard of the field test, the short-lived Sr^{89} and Cs^{134} were used in preference to the more hazardous isotopes, Sr^{90} and Cs^{137} . The hydraulic studies extended to a distance of 500 feet from the injection well, but after four months of operation, the 72

millicuries of Sr^{89} and 262 millicuries of Cs^{134} had traveled less than 63 feet from the injection well.

Ion-Exchange Theory

The available exchange capacity in a formation depends upon the total exchange capacity of the earth material, the partial exchange capacity occupied by the critical radiocation, and the fraction of this partial exchange capacity which can be utilized under practical conditions. The exchange capacity is a property of the medium and varies from nil in some sands to more than 100 milliequivalents (meq) per 100 g in the case of montmorillonitic clays. The partial exchange capacity for the critical radiocation is determined by the equilibrium with competing cations as expressed by the equilibrium constant. Consider the reversible reaction for a simplified system involving only two cations:



in which A is the cation in trace concentration (the radiocation) and B is the cation in gross concentration, a and b are the valences of A and B respectively, and clay represents the ion exchanger in the earth material. The distribution of cations on the clay may be expressed by the equilibrium constant:

$$K = \frac{(B^{+b})^a (A_b \cdot \text{clay})^b}{(A^{+a})^b (B_a \cdot \text{clay})^a} \quad (2)$$

The values within the parenthesis are activities, and the activity on the solid phase can only be measured experimentally or estimated empirically.

Vermeulen and Hiester⁽³⁾ have developed an empirical equilibrium parameter for trace conditions:

$$K'' = \left[\frac{(C_B^a \cdot q_A^b)}{(C_A^b \cdot q_B^a)} \right]^{1/b} \left(\frac{Q}{C_0} \right)^{a/b - 1} \quad (3)$$

in which C represents the concentration of the cation in the liquid phase in meq per ml, q represents the concentration in the solid phase in meq per g, Q is the total exchange capacity, and C_0 is the total cation concentration in the solution.

If the concentration of the critical cation in the effluent attains its maximum permissible concentration before much of the formation had become saturated, the fraction of the partial exchange capacity for this critical radiocation which can be utilized under practical operations conditions, or the efficiency of the system, would be low. This is determined by the steepness of the breakthrough curve. The shape of the breakthrough curve is a function of the equilibrium constant, rate coefficient, flow rate, and pore volume involved. Hiester and Vermeulen⁽⁴⁾ have prepared generalized breakthrough curves which define the shape for different values of their equilibrium parameter r, and column-capacity parameter s. The curves are normalized by plotting c/c_0 vs. Z. c/c_0 is the ratio of effluent concentration to influent concentration, and Z is a dimensionless function of the effluent volume, expressed as a fraction of the volume of feed solution required to supply sufficient equivalents of the cation in question to saturate the formation. Thus $Z = 1$ when the

volume of effluent equals the volume required stoichiometrically for saturation as measured by the area between the cation breakthrough curve and the chloride breakthrough curve. The authors⁽⁴⁾ originally designated Z as t/s . The column-capacity parameter s is defined as $k(vf/R)$ where k is the general rate coefficient which is a property of the medium and the reaction involved, v is the gross volume, f is the porosity, and R is the volumetric rate of flow per unit time. It has been shown that r is unity for trace conditions.⁽³⁾

Inasmuch as the capacity of the formation for the critical radiocation, V_a , is greater than for water by volume equivalent to the partial ion-exchange capacity, $q_A \rho v/c_A$, the cation front moves more slowly than the water front. This relation is expressed by:

$$\frac{F}{S} = \frac{vf}{V_a} = \frac{vf}{vf + q_A \rho v/c_A} = \frac{1}{1 + \frac{q_A \rho}{c_A f}} \quad (4)$$

where F is the mean velocity of the cation, S is the mean velocity of the water front, q_A is the partial exchange capacity for the cation as defined above, and ρ is the bulk density of the exchange medium. For a constant injection rate R , the ratio of the velocities is the reciprocal of the ratio of the mean time of arrival of the two fronts at any point in the medium. Thus,

$$\frac{\bar{t}}{T_A} = \frac{vf}{V_a} = \frac{F}{S} \quad (5)$$

where \bar{t} is the mean time of arrival of the water front, and T_A is the mean time of arrival of the cation front. Since $Z = 1$ when the effluent volume equals the volume required for saturation, and the time equals the mean time of arrival of the cation front, the time required for the effluent cation concentration to reach c/c_0 will be T_A times the corresponding value of Z , taken from the generalized breakthrough curves of Hiester and Vermeulen. Thus, if the value of F/S or vf/V_a and the value of the general rate coefficient, k , can be determined from laboratory columns of the formation material, and the mean time of arrival of the water front at any point \bar{t} can be measured in the field with a hydraulic tracer, then the column capacity parameter can be computed, and the mean time of arrival of the cation can be determined. Finally, by calculating the time required for the effluent concentration to attain various values, a breakthrough curve for the cation may be predicted at any point in the field.

Description of Well Field

Facilities for injecting the waste into a confined underground aquifer were installed at the Engineering Field Station at Richmond, California, during a study on the travel of pollution conducted from 1951 to 1953 by the University for the California State Water Pollution Control Board. These facilities have been described in detail in the technical literature.⁽⁵⁾ The aquifer was a water deposited unconsolidated pea-gravel and sand stratum averaging 4.4 feet thickness and confined between thick dense clay strata. The effective size of the aquifer material ranged from 0.20 to 1.5 mm, averaging 0.56 mm, with a uniformity coefficient ranging from 3.0 to 28, averaging 6.9. The aquifer was approximately 90 to 100 feet below the ground surface and about 75 feet

below mean sea level. The piezometric pressure was 13.6 feet above sea level and varied about 0.5 feet as a result of tidal swing in the nearby San Francisco Bay. The natural pressure gradient for the aquifer was about 0.003 from northeast to southwest.

Water for injection was supplied from the Field Station fire protection system. This highly mineralized water originated from a 30 foot aquifer not believed to be connected with the 90 foot aquifer used for this test. A mineral analysis is given in Table I.

TABLE I
Mineral Analysis of Injection Water, June 25, 1957

Cation	Concentration meq/l	Anion	Concentration meq/l
Na ⁺	3.04	HCO ₃ ⁻	4.54
K ⁺	0.05	SO ₄ ⁼	4.37
Ca ⁺⁺	3.60	Cl ⁻	4.29
Mg ⁺⁺	6.63	NO ₃ ⁻	0.45

The injection well was a 12-inch gravel-packed well which penetrated the aquifer. Water from the fire-protection system was supplied to a sump from which a triplex reciprocating positive-displacement pump took suction. This triplex pump supplied injection water to the well. The injection rate was approximately 35.5 gpm. In addition, a deep-well turbine pump was installed in the injection well to be used for redevelopment and for pumping tests of the aquifer.

The movement of the radioisotopes and the chloride tracers for water was followed by sampling from 23 wells located at distances ranging from 13 to 468 feet from the injection well in the pattern of a patriarchal cross as shown in Fig. 1. The wells sampled in this test were those in the south leg and north leg as well as four wells located 63 feet from the injection well. The test wells were six-inch wells with steel casings penetrating the confined aquifer and slotted at the level of the aquifer. Each test well was equipped with a 3/16" copper tube extending from the midpoint of the screen perforations to the surface. During injection operations, the piezometric head on the aquifer was sufficient to permit these sampling tubes to flow continuously. A truck-tire valve assembly on the well heads permitted measurement of the piezometric pressure with a mercury pot manometer.

Laboratory Studies

In order to predict the behavior of the synthetic waste during injection in the well field, extensive laboratory studies were carried out regarding the ion-exchange behavior of samples of aquifer material taken from seven of the test wells at the time these wells were drilled in 1951.

The exchange capacity of these seven samples was measured by the ammonium acetate method and found to vary only from 5.88 to 8.86 milliequivalents per 100 g, averaging 7.69 meq per 100 g. In view of the highly variable

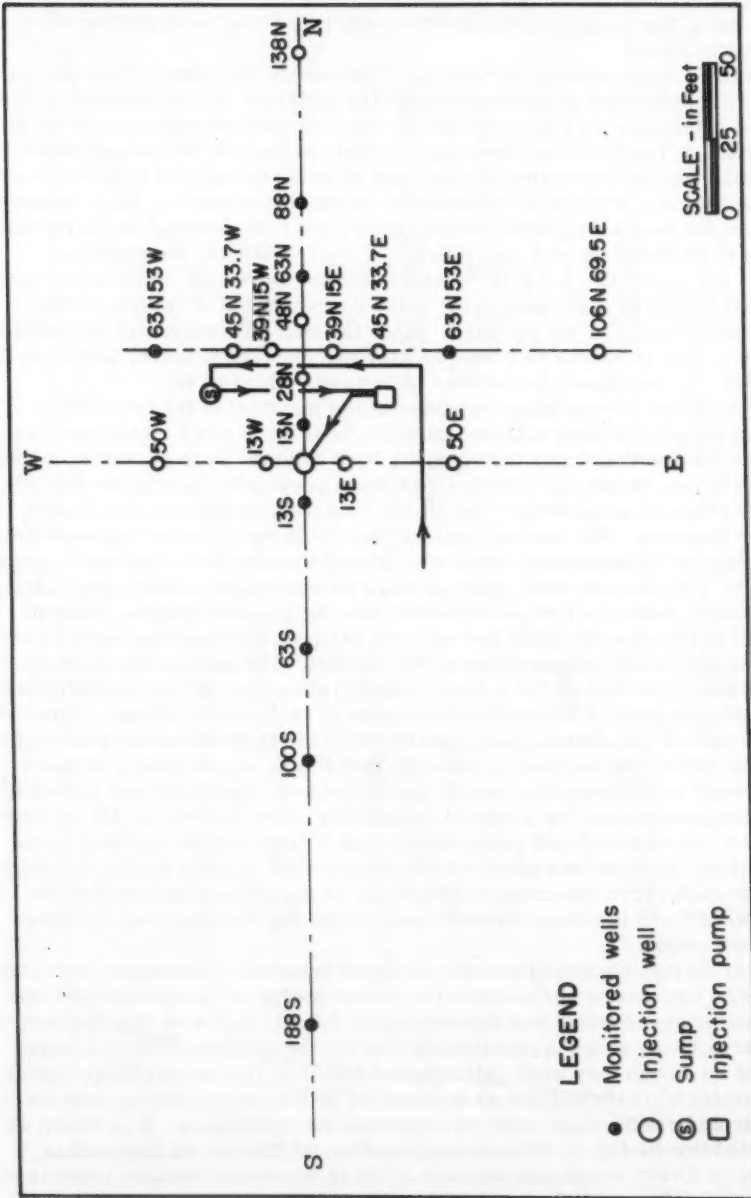


FIG. 1 - LAYOUT OF WELL FIELD

nature of exchange capacities for clay minerals, this variation is so small as to indicate, on one hand, that the aquifer is exceedingly uniform and, on the other hand, that random contamination with clay from the overlying stratum was insignificant.

Before column studies were made to determine the effect of the rate of travel of cesium and strontium through the material, it was considered desirable to determine the effect of varying concentration of cesium upon the rate of travel. It can be shown theoretically that, as long as the concentration is so small that the adsorption phenomenon is still represented by a linear isotherm, the rate of travel is independent of the concentration. By a series of batch experiments employing radiocesium tracer, the cesium isotherm was shown to be linear up to 2 mg cesium per liter, following the equation: $X/M = 1.8 \times 10^{-4} C + 2.7 \times 10^{-6}$, where X/M is the weight of adsorbed cesium per unit weight of adsorbent and C is the concentration of cesium in the supernatant liquid in mg per liter. Since the cost of cesium was too great to permit a dose in excess of 2 mg per liter and the rate of travel would not be affected at lower doses, no carrier cesium was added at all.

To study the ion-exchange behavior of the material in the laboratory, column techniques were selected because these were more representative of field conditions than batch techniques. Four columns were packed by adding dry earth into 19 mm I.D. Pyrex tubes while constantly tapping the side of the tube to effect close packing. The 58-cm long packing was held in place by rubber stoppers. The column material was first equilibrated with well water containing no radioisotopes which was passed through for an extended period of time. The columns were then operated on well water containing strontium and cesium, both of which were labeled with their radioisotopes. Solution was fed at the rate of 1.0 ml per min and samples were radioassayed to determine the cation concentration in the effluent. The cation concentration expressed as a fraction of the influent concentration was plotted against volume of effluent to produce a breakthrough curve of each of the cations. Fortunately, a complete chromatographic separation of the strontium and cesium was obtained within the two-foot columns so that it was not necessary to make differential radioassays for cesium and strontium. Breakthrough curves for strontium and cesium for a typical column are shown in Fig. 2. Of the four columns, one had such low permeability that it could not be operated in the laboratory. Another was operated for a short time to yield part of a strontium breakthrough curve, but clogged before any of the cesium appeared in the effluent. Efforts to obtain breakthrough curves for the other two columns were successful.

From earlier studies of the ion-exchange behavior of strontium in competition with calcium on various natural porous media, it was determined that the equilibrium constant was approximately 1.3.⁽¹⁾ Based on this assumption, together with the rough approximation that all the cations in the well water behaved as though they were calcium, and based on the ion-exchange capacity of the material in the column as determined by the ammonium-acetate method, a predicted breakthrough curve of strontium was calculated. It is shown as the dotted line of Fig. 2. The assumption that all the cations behaved as calcium is a very rough approximation, but is necessary because there is no theory presently available for handling the multicomponent system in which the strontium competes with more than one gross cation. The following qualitative observations regarding the effect of this rough approximation can be made, however. It has been shown in the earlier studies that calcium is

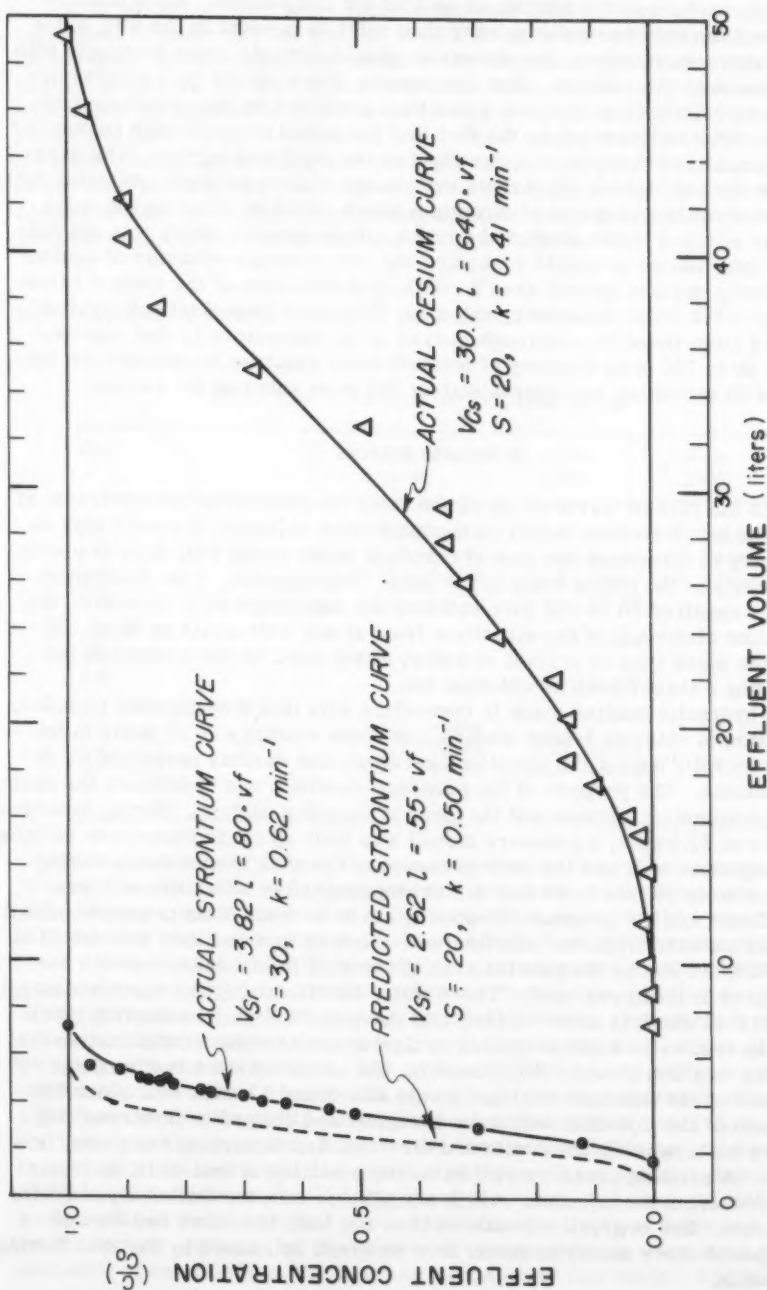


FIG. 2 - CATION BREAKTHROUGH CURVES FOR LABORATORY COLUMN F-3

favorably exchanged for sodium as well as for magnesium. Since these represent the only two cations other than calcium present in the well water to any appreciable extent, the strontium should compete more favorably with them than with the calcium. For this reason, there should be a greater uptake of strontium from the well water than predicted by this rough approximation. This is borne out by the fact that the actual breakthrough curves for strontium are in every case to the right of the predicted curves. The area between the two curves represents the volume of feed solution containing that number of milliequivalents of strontium which would be taken on the solid phase in addition to the predicted amount. Unfortunately, there was not sufficient information available regarding the ion-exchange behavior of cesium on different soils to permit even a rough approximation of the cesium breakthrough curve in the laboratory columns. The most important information obtained from these breakthrough curves in the laboratory is that approximately 80 to 100 pore volumes of solution were required to saturate the material with strontium and approximately 640 pore volumes for cesium.

Hydraulic Studies

Since the rate of travel of the cation front relative to the rate of travel of the water has been determined on the laboratory columns, it should only be necessary to determine the rate of travel of water in the well field to predict the velocity of the cation front in the field. For example, if the laboratory columns required 80 to 100 pore volumes for saturation with strontium, the mean time of arrival of the strontium front at any well would be 80 to 100 times the mean time of arrival of water, which must be determined in the field using a tracer such as chloride ion.

The hydraulic studies made in connection with this investigation included, in addition to chloride tracer studies, pressure readings at all wells in the field frequently during the injection operation, and various permeability determinations. The purpose of the pressure readings was to indicate the shape of the piezometric surface and the general injection pattern. During injection of water at 35.5 gpm, a pressure mound was built up in the immediate vicinity of the injection well and the peak pressure at the well rose steadily during injection from 39 feet to 55 feet due to clogging, after which the well was redeveloped and the pressure dropped again to 38 feet. This pressure mound extended outward from the injection well about 15 feet and then leveled off at about 30 to 32 feet in the general area of the well field. All elevations are referenced to mean sea level. These water levels are higher than the natural ground level which is about 20 feet, and therefore the small sampling tubes in all the test wells were permitted to flow under artesian conditions, so that sampling was facilitated. Unfortunately, one of the six-inch test wells at 463 feet south of the injection well and an old abandoned 12-inch well about 700 feet south of the injection well were uncapped and obliged to flow resulting in heavy withdrawal in the southward direction and disturbing the radial flow pattern. A semilog pressure profile on the south leg of test wells is linear to 100 feet from the injection well in accordance with the DuPuit equation for radial flow. But at greater distances than 100 feet, the curve breaks and corresponds more nearly to linear flow as would be caused by the overflowing south wells.

Three series of tests were made in the well field to determine the rate of movement of water and the time of arrival at each well utilizing chloride ion as a tracer. In each case, the chloride ion was added as both the calcium and sodium salts with these cations in the same ratio as naturally present in the well water, so that there would be no change in the permeability due to dispersion of the clay particles in the formation. Samples were analyzed for chloride concentration using the mercuric nitrate method,⁽⁶⁾ and the increase in chloride above background expressed as a fraction of the chloride dose was plotted against time after commencing addition of the chloride to produce a breakthrough curve. The mean time of arrival, defined as

$$\bar{t} = \int_0^{\infty} (1 - c/c_0) dt$$

was computed by planimetering the area behind these curves.

TABLE II
Mean Time of Arrival of Chloride Tracer

Well	June 1956	June 1957	Sept. 1957
13S	4.24 hours	3.6 hours	3.5 hours
63S	54.0 hours	49.0 hours	49.2 hours
100S	127 hours	91.5 hours	120 hours
188S		225 hours	
13N		7.50 hours	
48N	54.9 hours		
63N		68.0 hours	
50E	43.5 hours		
63N 53°E	85.7 hours	61.0 hours	
63N 53°W	118 hours	87.0 hours	
50W	77.3 hours		

The mean times of arrival for these three series of measurements are presented in Table II. A serious anomaly reflecting on the precision of the chlorides as a hydraulic tracer is the apparent early arrival of chlorides in all wells for which comparisons can be made in June, 1957, compared with June, 1956. It is possible that the earlier arrival in the south leg is due to a greater portion of the flow in the southward direction due to the overflowing of the 463-foot well and 700-foot well in that direction. However, it may be noted that there is an earlier arrival in all directions, and, inasmuch as the pumping rate was the same in 1957 as in 1956, there is no explanation of this phenomenon. For this reason, the experiment was repeated in September, 1957, and the results partly confirmed both of the earlier experiments, thus not resolving the anomaly. It was beyond the scope of this project to determine the chloride arrival at more than the south leg wells in September, 1957, but these were measured with good precision, and since the 463-foot south well had been capped to prevent overflow by the time these samples were taken, it appears that the September measurements were most representative of conditions at the time the cation study was made. For this reason, these values were used to predict the time of arrival of the cations.

The permeability of this aquifer was determined by three independent methods described by Wenzel.⁽⁷⁾ A series of pumping tests was conducted to measure the permeability by the Theis non-equilibrium method. The redevelopment well was pumped at about 35 gpm and drawdown measurements were taken at various times in all of the wells of the field. The transmissibility of the aquifer was calculated by the Theis method and the permeability was determined assuming an aquifer thickness of 4.4 feet. The permeability was determined by the Thiem method based upon DuPuit's equation for radial flow in a confined aquifer, by plotting the pressure profile for the south leg of wells during injection at 35.5 gpm on a semilog graph. The slope of the straight line obtained permitted calculation of the permeability by Thiem's formula. Chloride tracer studies provided a method of determining the permeability based upon the modification of the salt method. This was made possible by the fact that the mean time of arrival of the chlorides was a measure of the velocity of the water and hydraulic gradient was obtained from pressure profiles. Estimating the porosity to be 30 per cent, it was possible to calculate the permeability from Darcy's law. For comparison, the permeability measurements are all indicated in Table III.

TABLE III
Permeability of Formation

Well	Theis Method	Thiem Method	Salt Method	
	May 1957	July 1957	June 1957	Sept. 1957
13S	475*	1770	840	1070
63S	615	1770	1490	1770
100S	840		1685	1020
188S	418		1890	

* All values in gallons per day • foot²

The low permeability obtained by the Theis method may be due to the aquifer containing sewage solids as a result of injection of sewage about nine months earlier and the well never having been redeveloped before these tests were made. Immediately subsequent to the non-equilibrium tests, the well was heavily redeveloped to restore the permeability, particularly in the vicinity of the injection well. The permeability as measured by the other two methods are within an order of magnitude, and considering the sensitivity of the permeability to flow conditions and aquifer characteristics, it is felt that these values indicate a high degree of homogeneity of the aquifer formation.

In predicting the rate of travel of cations in an underground formation, the permeability is not necessary. It is only required that the velocity of movement of water under the conditions intended for operation of the disposal system be known. The use of chlorides as a tracer provides a suitable means of measuring this velocity directly, either under the intended conditions or for any other injection rate. The mean time of arrival at any point should vary inversely with the injection rate.

Field Test

Radiocations were applied to the well field by adding the radioisotopes to the injection water. The isotopes selected were strontium and cesium, because of the great health significance of these hazardous isotopes in fission products, and because these two cations have been intensively investigated as part of the program of study of the ground disposal of radioactive wastes. To decrease the hazard of injecting radioisotopes into a shallow aquifer and to reduce the hazard of contaminating well field equipment and site, Sr^{89} and Cs^{134} were used in preference to the long-lived Sr^{90} and Cs^{137} .

The dose in the feed solution was designed to be approximately one tenth of the maximum permissible concentration established by the Atomic Energy Commission and based on lifetime exposure for drinking water.⁽⁸⁾ The size of sample to be assayed was determined by this dose, the detection efficiency of the counting equipment, the maximum practical counting time, the background counting rate, and the confidence desired of the ability to count one per cent of the dose. The detection efficiency for strontium counted in an internal proportional counter was estimated to be 50%. The maximum counting time was considered to be about 20 minutes and the background was about 65 counts per minute. For 95 per cent confidence in the ability to detect one per cent of the initial concentration, the volume of sample to be analyzed was 150 ml.⁽⁹⁾ The actual dose of Sr^{89} was 1.8 mc per day or 0.94×10^{-5} μC per ml, and the dose for Cs^{134} was 7.5 mc per day or 3.8×10^{-5} μC per ml. The total of 262 mc of Cs^{134} and 72 mc of Sr^{89} was injected over the 40 day period.

The Sr^{89} furnished by Oak Ridge National Laboratory was carrier-free, so that the strontium concentration in the injection water was only the 1.5 mg per liter naturally present in the injection water. The injection water was assumed to contain no cesium and therefore the total cesium concentration in the injection water may be computed from the specific activity of the Cs^{134} obtained from Oak Ridge to be 2.6×10^{-6} mg per liter. Inasmuch as the cesium isotherm obtained in the laboratory indicated that there would be no speeding up of the cesium front by the addition of carrier cesium, up to 2 mg/l, and inasmuch as the cost of commercially available cesium in such large quantities was prohibitive, no carrier cesium was added.

The time of arrival of these two radiocations was predicted, for comparison with the experimental values and for use as a guide to sampling the monitoring wells. It was found that the volume of feed solution required to saturate the laboratory columns with strontium varied from 80 to 100, and averaged 90, pore volumes. It is evident then that the mean time of arrival of the strontium front at any well should be about 90 times the mean time of arrival of the water front as measured by the chloride tracer. Likewise the volume of feed solution required to saturate the laboratory columns with cesium was determined to be about 640 pore volumes so that the mean time of arrival of the cesium can be predicted to be about 640 times as long as required for the arrival of the water front. Table IV shows the predicted mean time of arrival of these various cations.

The isotope as received from Oak Ridge was diluted in distilled water to make one liter and 25 ml aliquots were carefully dispensed into test tubes. The contents of one test tube were added to an empty 40-liter bottle and the bottle was filled to the precalibrated mark with well water to provide 40 liters of stock solution, or about one day's supply. This was injected at the rate of

TABLE IV
Predicted Time of Arrival of Cations

Well	Mean time of arrival of water	Mean time of arrival predicted for cations	
		Strontium	Cesium
13S	3.6 hrs.	13 days	3.1 mo.
13N	7.5 hrs.	28 days	6.7 mo.
63S	49.0 hrs.	6.0 mo.	3.5 yrs.
63N	68.0 hrs.	8.5 mo.	5.0 yrs.
63N 53°E	61.0 hrs.	7.7 mo.	4.4 yrs.
63N 53°W	87.0 hrs.	11 mo.	6.3 yrs.

about 25 ml per minute by a Sigma pump through rubber tubing into the suction pipe of the injection pump. The dilution ratio at this point was about 10,000 to 1. Strontium and cesium were stored in separate bottles and fed through separate lines by the same Sigmamotor pump into separate connections on the suction pipe. A second 40-liter bottle was provided for each isotope as a reserve supply to be used while the regular feed bottle was being refilled, so that the injection was continuous. Each bottle was placed in a large tub which served as a secondary container in case of spill. Additional Sigmamotor pumps were used as transfer pumps to transfer the tailings of the solution left in the regular feed bottle over to the reserve bottle, so that the regular bottle could be empty when new solution was made up. This insured a uniform concentration of feed solution. A small amount of sodium hypochlorite solution was added to each batch of feed solution to control the growth of algae.

Samples of feed solution were collected at the injection pump and were analyzed to determine the concentration of isotopes in the injection water. 150 ml of the sample was evaporated to near-dryness in a beaker and then transferred to a 10-ml 2-inch aluminum culture dish, after which it was completely dried and counted in a windowless flow proportional counter to determine the total beta activity. A second sample consisting of 20 ml of the water was analyzed for Sr^{89} only by precipitating the strontium with ammonium oxylate using the method developed by Mizzan.⁽¹⁰⁾ This method permitted counting of the Sr in the internal proportional counter and it was found that the average strontium activity, corrected to July 1, 1957, amounted to 1130 cpm for a 150 ml sample. By difference the cesium activity was about 2430 cpm for a 150 ml sample.

Samples collected from the various monitoring wells were also analyzed for total beta activity by evaporating 150 ml in a beaker and transferring to a 10-ml aluminum dish for final drying and counting in the internal proportional counter. Since spot checking of a few samples by differential radioassay showed a complete chromatographic separation of the cations in the first 13 feet of the formation, there was no need to determine strontium and cesium separately. It was assumed that all activity first obtained at a well was strontium and this concentration rose from zero to almost 1.0 and was then reduced again to zero due to elution by additional water pumped after injection of the radioisotopes ceased. The strontium was completely eluted before any cesium arrived at the thirteen-foot wells. Thus all the activity in the first

"wave" was considered to be strontium and any activity appearing in a second "wave" was assumed to be cesium.

The strontium activity was corrected for decay to July 1, and plotted as a fraction of the strontium activity in the feed solution as of the same date against time to produce the breakthrough curves shown in Figs. 3 and 4. The predicted arrival of the strontium at these wells is also shown as dotted lines. This prediction is based on the average reaction rate for the laboratory columns as computed from the Hiester-Vermeulen generalized curves, and the predicted mean time of arrival of the cations at the well. Results for strontium arrival are available only at these two wells, because, as predicted in Table IV, the mean time of arrival for more distant wells is anticipated to be 6 to 11 months, and the system had been in operation for only 90 days at the time this paper was prepared. It was expected that the cesium should have begun to have appeared at the 13S well and should have been approximately half the concentration of the feed solution after 90 days, but after 94 days there had been no indication of a second wave of activity.

The field will continue to be operated for several months and the monitoring wells will be sampled periodically to trace the movement of the activity outward. The waves of activity should broaden and become less high as they move outward. It is hoped that a wave will be detected at the 63-foot wells, but it is doubtful that one will be detected at greater distances. The waves become smaller and the activity is constantly decaying, so their detection will become increasingly more difficult.

Some observations may be made from the actual breakthrough curves which reflect on the manner of operation of the system. The scatter of the points is greater in the case of the 13N well than for the 13S well. In the latter case, the points fall generally within about 5 to 7% of the curve of best fit. The error is due to variation in the feed solution activity, error in compositing of the sample within the reservoir at the bottom of the monitoring well casing, sampling error, and error in analysis, as well as statistical variation in the counting rate. The latter should be no more than 1.5 to 3%. The scatter of points is considerably greater during injection than during elution, which would seem to indicate that the variation in activity of the feed solution was considerably. However, a slightly different method of sampling was used during elution. Instead of sampling directly from the overflowing sampling tube in each well, the sample was allowed to flow continuously into a gallon jug, and collected after shaking so that the jug served to composite the sample over an integration period equal to the detention time of the jug, which was approximately 1 hour. This would tend to reduce the error due to lack of mixing time within the sampling well.

There are sudden changes in the curve on the 5th and 27th days in both cases. This would presumably be due to changes in the feed solution. A review of the operating log shows that on the 7th day, one of the rubber tubes in the Sigma pump broke. Another Sigma pump was used for about 30 hours until this one could be decontaminated and returned to service. The substitute pump had a lower feed rate than the regular pump. The break in the curve for the wells occurred prior to this time in each case, however. The injection of water was interrupted for 2-1/2 hours on the 22nd day due to failure of the water supply to the sump. There is no indication of any change in operation on the 27th day, however, and the interruption of the 22nd day would have been reflected in the results before the 27th. In summary, no account has been found for these two breaks in the saturation curves.

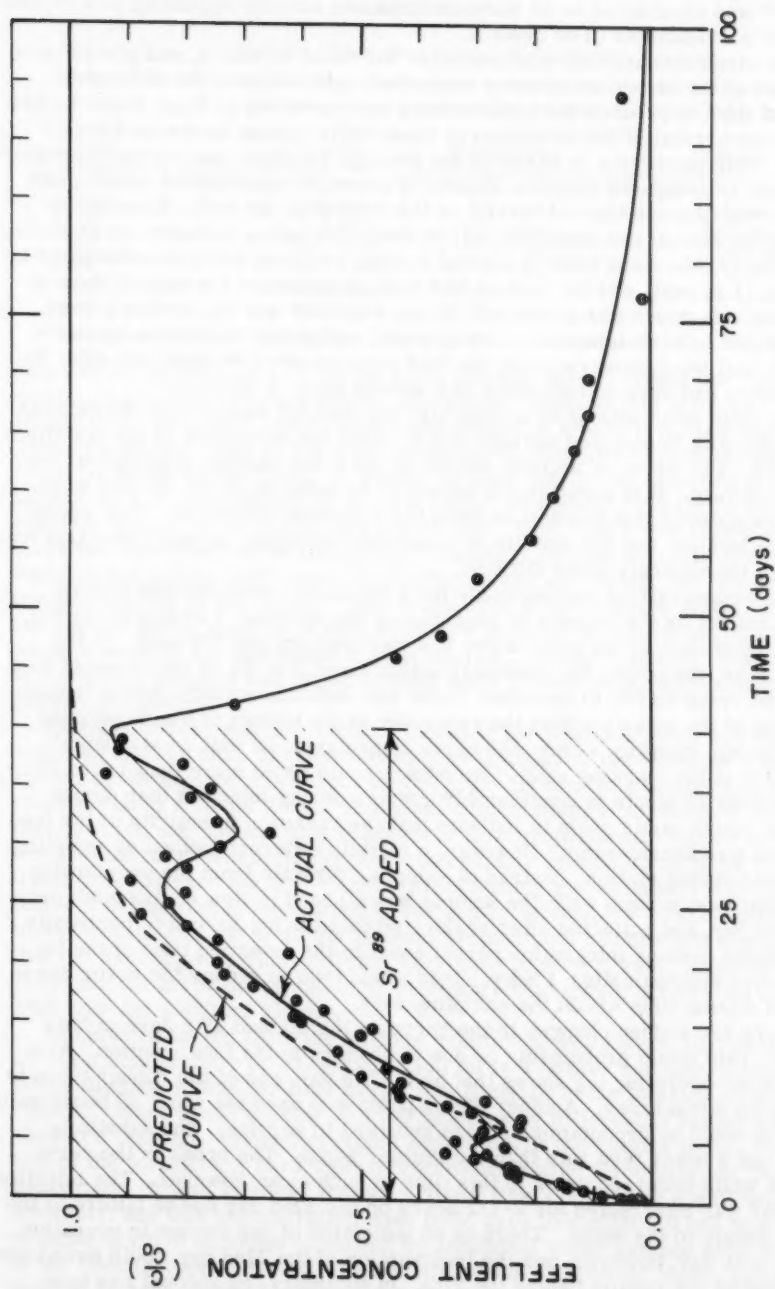


FIG. 3 - STRONTIUM BREAKTHROUGH CURVE FOR WELL 13S

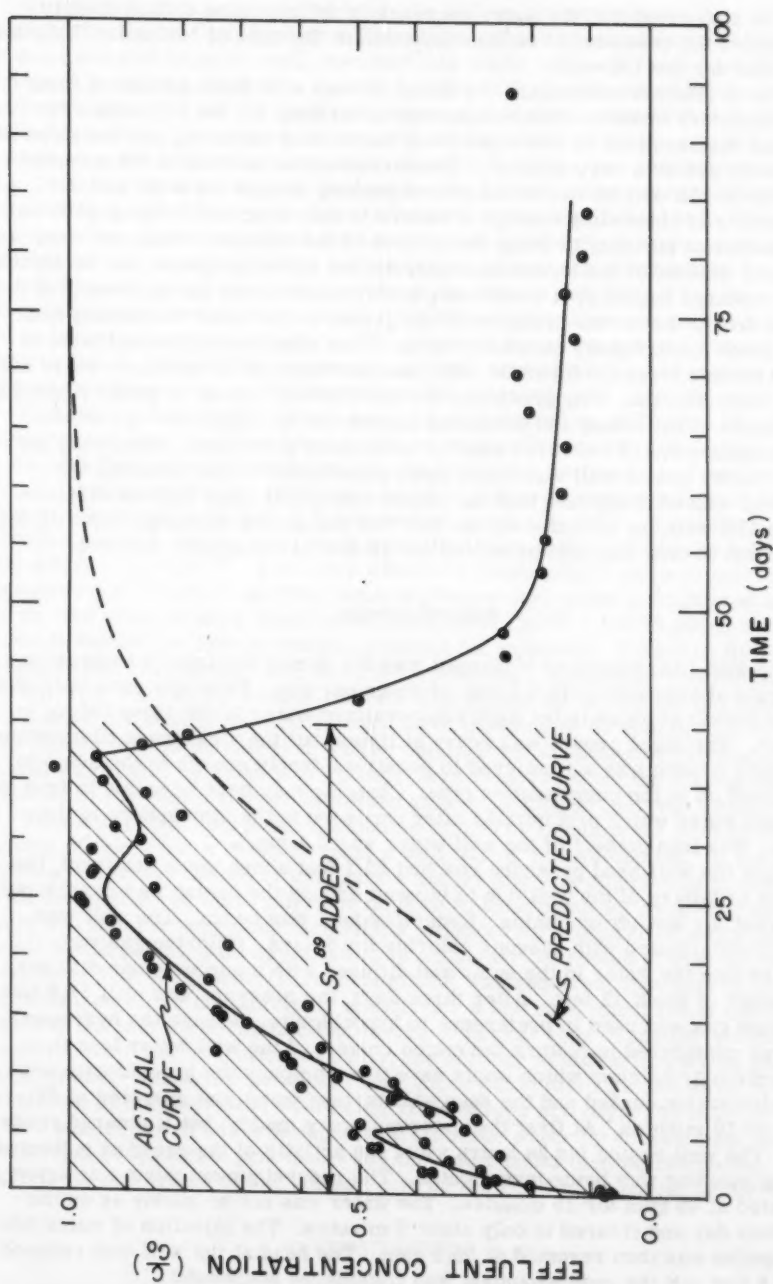


FIG. 4 - STRONTIUM BREAKTHROUGH CURVE FOR WELL 13N

It is also noted that the sharp decrease in activity upon elution clearly preceeded the cessation of isotope injection in the case of 13N well. This was not noted for the 13S well.

It is of interest to compare the actual curves with those predicted from the laboratory studies. The comparison is striking for the 13S well. The general displacement of the curve from the time of beginning and the slope of the curve are both very similar. The earlier initial arrival of the strontium activity in 13S may be due to the gravel packing around the well, and the possibility of channeling through a fissure to this near well. The gravel wall has sufficient porosity to delay the arrival of the chloride tracer, as much as an equal amount of the formation material, but since the gravel has no significant exchange capacity, it would not proportionally delay the movement of the cation front. Hence the presence of the gravel could cause the cations to arrive much more rapidly at nearby wells. This effect would be negligible at wells farther from the injection well, and in a large field operation would not need consideration. The prediction for the 13N well is not so good. Although the slopes of the actual and predicted curves are in reasonable agreement, the displacement of the curve was not accurately predicted. Apparently the effect of the gravel wall was much more pronounced in the northerly direction. Indeed it appears that the gravel extends at least half the distance to the 13N well, as indicated by the fact that the partial exchange capacity for strontium is only half that predicted for 13 feet of the aquifer material.

Redevelopment

The well head pressure increased steadily during the injection operations at a rate of approximately 0.2 feet of water per day. This may have been due to the growth of algae in the highly mineralized water in the sump before injection. The algae growth was heavy at times, but the algae were filamentous and their growth was not believed to penetrate deeply enough in the sump to be picked up in the pump suction pipe. Clogging may have been due to iron in the well water which precipitated after exposure to the atmosphere in the sump. The iron content of the well water was 1.1 mg/l.

After the well head pressure reached 55.1 feet above mean sea level, the danger of failure of the well due to blowout around the casing was considered too great for further operation. Redevelopment was begun. The well was heavily chlorinated with gaseous chlorine for 3 days. Chlorine gas was bubbled into the water in the sump and diffused with a porous stone diffuser at a depth of about 12 feet. After three days, the pressure was still 51.8 feet. Chlorine gas was used in preference to hypochlorite, because the hydrogen ion was considered to disturb the cation content of the well water less than the sodium or calcium which would have to accompany the hypochlorite ion.

Chlorination ceased and the deep well turbine pump was operated at 47 gpm for 16 minutes. At first the water was very muddy, but it cleared gradually. The well rested for 24 hours while the activity of the samples collected during pumping was being investigated. The redevelopment pump was again operated at 45 gpm for 15 minutes. The water was not so muddy as on the previous day and cleared in only about 5 minutes. The injection of water into the aquifer was then resumed at 35.5 gpm. The head at the well was reduced to 37.6 feet and the redevelopment was considered successful.

Samples of the water pumped from the well were carefully analyzed to determine the amount and kind of radioactivity and the physical form in which it was produced from the well, because this might well represent a serious problem in the operation of a system for disposal of radioactive wastes by underground injection. Analysis of evaporated samples showed that the total activity removed from the well was 1.71 mc or 0.51% of all the activity injected over the 40 days of operation. About 2/3 of this was removed during the first 16-minutes pumping operation. The activity of samples taken at various times was very closely correlated with the rise in solids in the water pumped from the well, so that the activity was apparently largely on the suspended solids. Counting of the suspended solids and dissolved solids for each sample as separated by molecular filtration showed that 97% of the beta activity was on the suspended solids. It was found that these suspended solids were largely clay and the activity was retained by ion exchange. Treatment with peroxide showed the presence of a small amount of organic matter in the suspended solids, but its decomposition released only 1% of the activity. Acid soluble fraction of the suspended solids retained an additional 1% of the activity, but this may have been removed from exchange sites by hydrogen ions. All the rest was held to clay particles by ion exchange, and was so favorably attached to the clay that only 10 to 15% was removed in each of two successive treatments with 1 N ammonium acetate at 100° C for several days. Gamma ray spectrograms of each of the fractions indicated that the bulk of the activity was Cs¹³⁴. Extensive efforts to identify Sr⁸⁹ were completely unsuccessful. Gamma spectrograms of yttrium-hydroxide precipitated activity showed some activity which is believed to be Ce¹⁴⁴ - Pr¹⁴⁴ which was a contaminant of the radiostrontium obtained for injection. This activity was negligible in comparison with the Cs¹³⁴, however. Apparently the two days of injecting well water without radiocations pushed the strontium out into the formation far enough that the 31 minutes of pumping at 45 gpm did not bring out enough clay to include that which contained the strontium. The cesium, which was traveling much more slowly, was removed when the clay in the vicinity of the well and even within the gravel packing proper was removed.

This study indicates several possible means of reducing the hazard of disposing of the activity removed from a well during redevelopment. If the injection water was devoid of particulate matter and was completely compatible with the formation, there might be no need to back pump for redevelopment. Injection into the very deep formations proposed for radioactive waste disposal would permit safe operation at much higher well-head pressures without requiring redevelopment. If redevelopment was required, injection of highly mineralized water containing no activity for a few days might leach the radioactivity out into the formation far enough to permit redevelopment without its removal from the formation. Finally, the activity would be largely on the solid phase. Hence low pumping rates which would dislodge and wash out a minimum of clay and sand would also remove less activity. The activity which was removed could be separated from the water by conventional sedimentation or filtration processes and the water could then be reinjected. The activity concentrated on the solids could be disposed of by burial or storage.

CONCLUSIONS

An attempt has been made in this series of tests to determine whether the fate of a radioactive waste, or at least its radioisotope most critical from the

health standpoint, can be predicted from laboratory studies of the ion-exchange behavior of the material in the formation, and field studies of the hydraulics of the formation. For strontium, it was concluded that such predictions can be made with reasonable accuracy. To date, due to its extremely low rate of movement, sufficient data regarding cesium have not been obtained to draw definite conclusions. It would appear that the prediction of cesium movement will be less precise, possibly because the strong affinity of the clay for cesium makes this isotope very sensitive to conditions of flow and formation characteristics. Since it moves more slowly than strontium and since strontium has a lower maximum permissible concentration in the environment, it is not likely that cesium would be critical in determining the capacity of a formation for a radioactive waste.

The following specific observations have resulted from this study:

1. In order to insure representativeness, several samples of material from the formation should be studied in the laboratory as a basis for predicting behavior in the field. Laboratory studies of samples from this field showed it to be exceptionally homogeneous.
2. The cesium adsorption isotherm was shown to be linear below 2 mg per liter in the solution phase. Carrier cesium below this concentration would not affect the rate of travel through the formation.
3. Mean breakthrough in the saturation of laboratory columns required 90 pore volumes of feed solution for strontium and 640 pore volumes for cesium.
4. Reasonably accurate predictions based on earlier work with other media were made for strontium behavior in the laboratory columns. Such predictions were not possible with cesium.
5. Chlorides are satisfactory hydraulic tracers if they are used in sufficient concentration to be detected in the natural background of chlorides and sufficient care is taken in sampling and analyzing. The chloride dose should not be so great as to cause serious differences in density and care should be taken to insure that changes in cation composition of the water do not bring about undesirable changes in permeability of the formation.
6. Permeability, measured by three methods, indicated that the formation was reasonably homogeneous.
7. The appearance of strontium in one of the wells was predicted quite accurately, but the strontium appeared at the other well in half the predicted time.
8. The cesium arrival at the 13S well was later than predicted. Data for other wells were not yet available.
9. The formation had a very high capacity for strontium and a much higher capacity for cesium. The cesium traveled so slowly that a 40-day dose was completely separated from the strontium within 13 feet.
10. The breakthrough curves were very flat at nearby wells and would probably be flatter at more distant wells. There would be less tendency at the distant wells for the cations to rise in concentration rapidly at first appearance due to short-circuiting of solution through channels. Effluent monitoring will be simplified by the ample warning afforded by this slow breakthrough of the critical isotopes.

11. Redevelopment of the well by pumping produced some Cs^{134} activity which was essentially all held on the clay particles by ion exchange. No Sr^{89} was removed by the short pumping required for redevelopment.

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TREATMENT OF LIQUID RADIOACTIVE WASTES

Conrad P. Straub,¹ M. ASCE

In the sections that follow, the experience of several Western European countries in the handling, treatment, and disposal of liquid radioactive wastes is reviewed. The information presented was obtained while visiting in these countries during the period September 9 to October 11, 1957.

United Kingdom

Routine liquid radioactive wastes are treated at Harwell by the addition of caustic soda to raise the pH to 9.5 to 10, of 50 to 100 ppm of PO_4^{-3} , and of acid to lower the pH to 7 to 7.5. By this treatment about 90 per cent of the alpha activity and 60 to 85 per cent of the beta activity is removed. If alpha activity is high, it can be reduced to background by acidification with H_2SO_4 to pH 3 followed by the addition of 10 ppm analytical grade tannic acid. The pH is then raised to 9 with lime, 110 ppm PO_4^{-3} is added, and the precipitate removed in upflow (sludge blanket) type units. To improve operation, the calcium phosphate floc is being weighted with about 3 ppm $\text{Fe}(\text{PO}_4) \cdot 2\text{H}_2\text{O}$.

As a second step in the treatment process for low level wastes, the upflow effluents are passed through vermiculite columns. If the total decontamination obtained is insufficient to allow discharge to the Thames River, the effluent may be returned for retreatment or it may be stored and released following dilution with less active wastes.

The chemical sludges or precipitates are dewatered presently by freezing. This method, originally developed for dewatering organic type sludges, e.g., sewage sludge, was tried with the crystalline chemical sludges and found to work well. The radioactive sludges are frozen by means of conventional units, thawed, and immediately dewatered. Prolonged standing after thawing or mixing vitiate the dewatering benefits of freezing.

Following dewatering, the sludges are placed in drums, and hauled every six weeks or so to the east coast of England for disposal off the Channel Islands in water 65 fathoms deep. During transit, the transport is accompanied by laboratory personnel. Radiation levels on the surface of the drums

Note: Discussion open until June 1, 1959. To extend the closing date one month, a written request must be filed with the Executive Secretary, ASCE. Paper 1930 is part of the copyrighted Journal of the Sanitary Engineering Division, Proceedings of the American Society of Civil Engineers, Vol. 85, No. SA 1, January, 1959.

1. Radiological Health Program, Robert A. Taft San. Eng. Center, Public Health Service, Dept. of Health, Education, and Welfare, Cincinnati, Ohio.

shall not exceed 2 M. P. L. (1 M. P. L. = 0.3 r per week), except that not more than 10 per cent of the drums may have a radiation exposure of 10 M. P. L. at the surface.

Small containers of higher activity liquid waste are placed in small drums of five-gallon size, broken and the liquid taken up in lime, placed in a larger container, shielded with concrete to the exposure levels indicated earlier, and disposed of in the English Channel. Some shipments are also disposed of in the Atlantic Ocean, but at depths of 2,000 fathoms.

Intermediate level wastes are batch-treated by phosphate coagulation, as described, until suitable for discharge to the Thames River. Higher level wastes, on the other hand, go to a separate treatment plant, where special precipitation techniques are provided. The sludge is handled as described, and the filtrate passes to an evaporator.

A more extensive system of waste treatment for low level wastes has been suggested by Dr. Amphlett, and is directed to the reuse of effluent as process water. The procedure involves three stages of treatment, namely: (1) flocculation with lime, phosphate, and iron, (2) passage through vermiculite beds, and (3) deionization in an electrolytic ion exchange unit. The effluent from this plant will approach deionized water and will be reused in many laboratory operations presently utilizing mixed bed deionized water. By such a recycling system, the total quantity of water required would be reduced, thus cutting down the cost of deionized water and resulting in a much smaller discharge of liquid wastes from the Harwell establishment.

The sludge from the flocculation treatment will be dewatered, with return of filtrate to the flocculation units, and will be combined with other solid wastes for further processing to fix the activity by heat treatment. After firing and fixation, the unleachable solid wastes would be stored at some suitable location.

High level laboratory wastes will be collected in separate containers, evaporated or subjected to a precipitation process as required. If evaporation is used, the condensate will be mixed with other low level wastes and go through the treatment process described earlier. The chemical sludges, produced during the precipitation step, will be mixed with solids coming from the low level flocculation plant. Following the addition of silica, fluxes, etc., the material will be fired and the unleachable solids will be stored.

This three-step treatment process is expected to provide a decontamination of about 10^3 to 10^4 . The volume of wastes to be handled will amount to approximately 500,000 gallons (Imperial) per day.

An interesting observation made by Dr. Amphlett concerned the selective retention of strontium over cesium by the vermiculite they studied. Some preliminary results indicated that the cesium broke through the columns after a throughput of about 50 volumes, whereas the strontium required about 700 volumes.

At Windscale, wastes other than those obtained from direct reprocessing of fuel, are neutralized before passing to holding tanks. Alum is added and the wastes are passed through sludge blanket units. By such treatment about 80 to 90 per cent of the beta activity is removed. The basic problem here is the removal of ruthenium since it controls the amounts of waste that may be discharged into the Irish Sea off the coast of England. As many of you know, the ruthenium in the waste is adsorbed on a fine ribbon type of seaweed—Porphyra umbilicalis. This seaweed, which is used by the Welsh for making

a black glutinous product called laverbread, is about one cell thick with an enormous surface area.

Studies are under way to find methods that may be used to complex the ruthenium, thus preventing its uptake on the fine iron particles which are present in the sands of this area. It has been found that these ruthenium coated particles accumulate in the gills of marine forms and that the gills are cleansed of the particles when they are placed in clean water.

About 1-1/2 mc/month of radium and some uranium is discharged along with the effluent from Springfields where uranium metal is purified and fuel elements are fabricated. The wastes are discharged to the estuary and are not treated as a serious problem. Almost all measurements of activity are made on muds, since these materials accumulate there.

Denmark

Denmark has a 5W Water Boiler Reactor from Atomics International, which is located at Riso on a peninsula about 30 kilometers west of Copenhagen. A plant is under construction at the site to concentrate, by evaporation, the small amounts of waste being produced. The evaporator concentrates will be mixed with concrete and placed in drums for above ground storage. At present the waste volume is very small coming from low level laboratories, from semihot cells where work is carried out at 10-20 mc levels, and from hot cells which process experimental fuel element types tested in the reactor.

There are no regulations relating to the discharge of low levels of activity from hospitals and other sources using radioisotopes. In general, water dilution is provided and the spent isotopes are discharged to the sewer. Urine containing radioactive iodine, for example, is collected separately, monitored, stored for 4 or 5 days, and stable sodium iodide is added before discharge.

Norway

The Joint Establishment of Nuclear Energy Research (JENER) is located at Lillestrom, some 15 miles east of Oslo. Here, the JEEP reactor went critical in July 1951. It is of the CP-3 type fueled with natural uranium, cooled, and moderated with heavy water. Operating at 450 to 500 kw with a neutron flux of 10^{12} neutrons/cm², it is used for physics experiments, neutron spectroscopy, and isotope production. The bulk of the wastes produced come from isotope separations, although other fission product wastes are produced from fuel dissolution which is practiced on a very small scale, primarily for experimental purposes.

Iodine-131 containing waste from chemical separations is stored and controlled quantities are released to the river. The Establishment would like to have levels of discharge established similar to those used at Harwell for release of activity into a stream environment. Plans are under way to provide a waste treatment and disposal facility on site for treating low level wastes produced in the isotope building, metallurgical and chemical hot cells, and in the existing chemical building. About 23 m³/day will be treated in a plant providing facilities for the addition of Ca⁺⁺ to raise the pH in the first upflow unit, followed by NaOH and PO₄⁻³ in the second upflow unit. The chemically treated effluent then passes through a two-stage filtration unit with anthrafil

in the first stage and vermiculite in the second stage. The sludges produced will be stored in drums and held until permission is granted for sea disposal. At the proposed levels of operation, it is estimated that three 250 liter drums of sludge will be produced per month for disposal.

Sweden

The Swedish Atomic Energy Company has under construction a reactor and atomic energy research station at Studsvik, about 45 miles south of Stockholm on the eastern coast. Considerable study has been given to the kinds and quantities of wastes that may be produced at this site. These wastes have been categorized into 8 groups, four of which will be radioactive, as shown in Table I.

Table I: Estimated Daily Quantity and
Activity of Liquid Wastes

	<u>Category of Waste</u>	<u>Activity</u>	<u>Quantity m³/day</u>
I	1st Cycle Raffinate (Plutonium separation plant) (Plutonium 2nd and 3rd cycle)	15kc	1.3
II	2nd and 3rd Cycle Raffinate	15-30c	20
III	Active Laboratory Wastes (Research Laboratories)		
IV	Outlet Water (Miscellaneous Wastes)	0-15c	100
V	Cooling Water and Fire Extinguishing Water		
	-- Fresh Water		100
	-- Salt Water		105,000
VI	Sewage		275
VII	Water from Areas Surrounding Active Buildings - 1.2 inch rain		660
VIII	Water from Non-Active Areas		---

Category I wastes from the first separation column will be stored in acid proof steel tanks in underground rock excavations following evaporation. The condensate will be combined with Category III wastes.

Category II wastes include the 2nd and 3rd cycle raffinates. These wastes will go to steel tanks for monitoring, followed by evaporation and storage of concentrate. The condensate will be combined with Category III waste. The more active wastes from Category III would be bypassed directly and combined with Category II wastes for treatment by evaporation.

Category III includes wastes from hot laboratories, condensate from Categories I and II, and all other active wastes. This category is connected

with the chemical treatment plant or evaporator. If, after monitoring, the effluent or condensate activity is low enough, the waste will be discharged into the channel between Stora Bergo and Stutsviksholme. The evaporator concentrate will be added to the Category II concentrate storage facility. Present thinking with regard to this category of waste is that aluminum hydroxide, ferrous sulfate, and tri sodium phosphate may be used as coagulants, following in general British practice at Harwell, with filtration of the clarified effluent through sand and vermiculite beds. From 67 to 90 per cent of the radioactivity may be removed and provision will be made for recirculation as needed. The low level sludge will be dewatered and buried on site. Ion exchange facilities will be provided for use in case of emergency or unusual peak loadings.

The wastes comprising Categories IV, V, VI, VII, and VIII are grouped as being nonactive wastes. However, if activity above prescribed levels is found in these wastes, they will be combined with Category III wastes and treated as already indicated. After monitoring, these waste streams will be discharged into Lake Tvären.

France

The treatment of low level liquid radioactive wastes at Saclay follows British practice very closely. Phosphate coagulation is utilized with 100 ppm phosphate and 100 ppm tannin added. It is claimed that the tannin speeds up flocculation and is helpful in the removal of strontium. The calcium phosphate precipitation at a pH of about 11 to 12 results in a volume reduction of about 50, produces a sludge having a moisture content of about 89 per cent, and provides a decontamination factor of about 25.

A truck is used to haul the decontaminated liquid to Chatillon, located about 15 km from Saclay, where it is discharged into the sewerage system for treatment with Paris sewage before release to the Seine River.

The sludge is dewatered, placed in 55-gallon steel barrels, and stored above ground in a building located near the treatment plant.

At the reactor site at Marcoule, it is expected that about 200 m³ of acidic waste (pH - 0.5) will be produced daily having an activity level ranging from 1 to 3 c/m³. High level wastes will amount to 5 to 50 m³/yr, depending on the composition of fuel elements processed. The low value is for processing natural uranium and the upper value for processing alloyed fuel elements. These wastes will be evaporated to an activity level of something in the order of 500 curies/liter, varying from 200 to 1,000 curies per liter.

Special treatment is being considered for the intermediate level wastes because the radiochemical composition is quite uniform. The studies outlined include the following: (1) different phosphate treatments, (2) influence of neutralizing agent, (3) acid treatment, (4) adsorption in acidic form on metallic powders, (5) improved decontamination of cesium, and (6) adsorption in alkaline pH after chemical treatment.

For high level waste treatment formation of glass is the first consideration, followed by ceramic formation. Calcination may be studied in the future. With regard to ultimate disposal of wastes, contracts have been made with other governmental agencies to study the possibilities of underground discharge or sea disposal. The initial studies are being carried out to evaluate the possibilities of releasing low level wastes and contaminated sludges into either of these two media.

Netherlands

Because of ground water conditions in the Netherlands, it is impossible to consider disposal of radioactive wastes into the ground. Accordingly, present thinking is concerned with the possibilities of utilizing evaporation even for low level waste treatment, with storage of the solids in containers above ground until such time as sea disposal is resolved.

Considerable progress has been made in the Netherlands in the possible application of electrodialysis for desalting sea water. There is some interest, therefore, in the use of this method for the removal of ionic constituents from liquid radioactive wastes.

Belgium

The Belgian atomic energy facilities are located at Mol. Liquid radioactive wastes cannot be discharged into a canal flowing by the plant site to Antwerp. The wastes are pumped to the River Mol Nethe which has a flow of 50,000 m³/day. The permissible amounts of radioactive materials that may be discharged have been established by the Ministry of Health and follow British practice. On this basis, about 8 mc of activity may be discharged daily, but it is felt that these levels will have to be increased to 50 to 100 mc/day. This may be possible without exceeding permissible levels, because it is stated that there is considerable error in estimating the flow of the river. (The levels are based on a flow of 8,000 m³/day when the actual flow is 50,000 m³/day).

Treatment of the low level wastes follows British practice, in general, at least insofar as chemical treatment is concerned. However, instead of passing the chemical effluent through vermiculite, it is passed through columns of sawdust, either fresh or rotted. The claim is made that sawdust has the added advantage of being incineratable, thus reducing the amount of material that has to be disposed of by burial either on land or in the sea. More recently, brown coal or lignite is being studied for use in place of the sawdust.

De Jonghe divides the wastes to be treated at Mol into three categories as follows:

- (1) Cold water—activity level about drinking water tolerance or about 10⁻⁶ uc/ml. This waste consists of sewage, cooling water, and water from non-radioactive laboratories. At present it amounts to about 200 m³/day, but it is expected to increase to about 600 m³/day. Treatment consists of neutralization with CaO (sometimes with Al₂(SO₄)₃ · 8H₂O) followed by passage through trickling filters. Gross beta-gamma activity reductions of about 65 per cent are expected. The trickling filter effluent has a B.O.D. of 18 ppm.
- (2) "Tiede" or intermediate level wastes—activity level about 10⁻³ uc/ml. This waste comes from all active laboratory areas; cleaning, rinse, and tracer discharges; and the discharge from the reactor canal. It amounts to 30 m³/day. The final treatment plant to process these wastes has not been completed, but a pilot plant capable of treating up to 10 m³/day is in use. Treatment includes calcium phosphate precipitation, iron salt precipitation, and brown coal filtration. A decontamination factor of 50 is obtained. There is considerable concern over the excess use of Versene and other complexing agents which interfere with the operation of the treatment plant.

- (3) Hot wastes—activity level about 1 uc/ml. Nothing has been done in the way of specifying treatment for these wastes. For the present, they are stored. On the one hand, consideration is being given to evaporation as a treatment scheme, and on the other hand, either ordinary chemical treatment or specific chemical treatment is being investigated.

With the location of the OEEC (Organization of Economic European Cooperation) chemical processing plant at Mol, provision will have to be made for handling reprocessing wastes. DeJohnghe feels that ideas other than evaporation should be considered when plans are made for treating these reprocessing wastes.

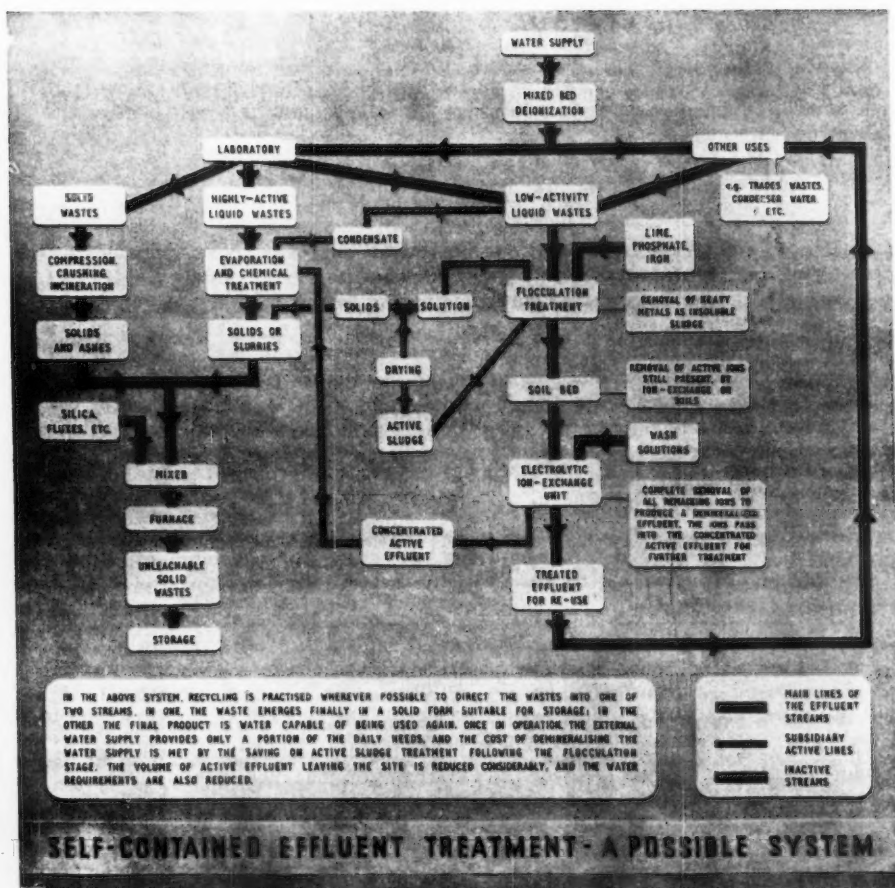
Germany

The extensive use of ground water for water supply purposes precludes utilization of the ground as a means of disposal for liquid radioactive wastes. Furthermore, permission has not been granted by the Ministry of Health to discharge any radioactive materials into surface waters. These two factors restrict the release of any radioactive materials into the environment. As a result, German thinking with regard to radioactive waste disposal is essentially containment at the site either in liquid or solid form.

In the first German reactor, a light water moderated swimming pool reactor located at Garching 15 km north of Munich, deionized water is used as the coolant in the primary circuit and ground water in the secondary circuit. Any radioactive materials in the primary coolant will be removed when the coolant is passed through mixed bed ion exchange resins. Open basins are provided for the storage of other wastes. These wastes will be monitored and, if found inactive, will be discharged to a small stream (flow 2 m³/sec) located at the site.

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I wish to express my appreciation to the many persons with whom I conferred during this trip abroad, who were kind and patient in answering my many questions, and who provided the information that makes this paper possible. In the interest of space I regret that I cannot list all of their names.



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WATER POLLUTION IN OUR CHANGING ENVIRONMENT^a

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A truly remarkable job has been done in this Nation of ours in conserving and promoting the health and comfort of the people. A great segment of this world-renowned accomplishment has been the result of environmental improvements and controls. These are primarily responsible for eliminating or bringing under control diseases such as cholera, yellow fever, typhoid, dysentery, malaria, typhus, and other diseases transmitted through insanitary environmental conditions.

The sanitary engineer and his colleagues rightly deserve the "lion's share" of credit for leadership in this basic part of our Nation's development and progress, although there is no time or place for complacency or "resting on our laurels." On the contrary, the rapidly advancing and changing technology, expanding industrialization, and rapid population increases have great impact on the food consumed, the water drank, the air breathed and the places of living, working and playing. Our accelerated technological and industrial progress presents challenges to government, industry, and, indeed, to the citizens themselves. Everyone must be able to live comfortably with and enjoy the products of the Nation's technological skills and natural resources. The challenges are great, and the problems are becoming more and more complex. These factors are especially applicable to water, one of our major concerns in the field of environmental health.

Water is an enigma. It is a most precious commodity to human life on this earth, yet man regards it as most commonplace. On the one hand it is highly perishable, while on the other it is almost indestructible. Depending on circumstances, it can be both priceless and worthless, a blessing or a curse. Man cannot live within it; neither can he live without it.

While water means different things at different times to all kinds of men, one thing is certain—water is basic to the life of man and vital to all segments of his economic activities. Water serves more in the fulfilling of human needs, directly or indirectly, than does any other natural resource. Like

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- a. Presented at the Southern Municipal and Industrial Waste Conference, Durham, North Carolina, May 1, 1958.
1. Regional Engr., Region III, Public Health Service, U. S. Dept. of Health, Education, and Welfare, Charlottesville, Va.

other goods that are essential to human needs and desires, the value of water is determined by its availability and usability and by the extent to which it is needed and used.

Through civilization man has struggled to avoid living in the environment of other men's wastes. The success of this struggle during any period in history has been largely a measure of the degree of civilization attained at that time. The Greeks, the Persians, the Egyptians, and the Romans attained high levels of civilization which were supported in large measure by good sanitation practices, especially in water supply. Paradoxically, during the decline of these civilizations, history shows that there were increasing problems involving natural resources, particularly water shortage and stream pollution. Time moved slowly in the distant past, and the rise and fall of these ancient civilizations required many centuries.

Calendars and clocks move much more swiftly now. Less than a hundred years ago America's young industrial giant was just beginning to flex its mighty muscles. A great nation stretched from sea to sea, and its tremendous natural resources seemed endless. Now, the country has reached a period when survival as a great nation is dependent on the ability to conserve and use wisely the remainder of these very same resources which once seemed so abundant.

America is in a period of unpredicted and unprecedented population and industrial growth. Population projections are continually being revised upward. Production to support the increasing population, the necessity to develop a technology for world survival and the insatiable appetite for even higher living standards have pushed industrial production estimates ever higher.

At the close of World War II it was believed that by 1975 the population of the United States would level off at about 170 million persons and remain relatively static thereafter. Instead, the explosiveness of our postwar growth is shown by the fact that we have already passed the 170 million mark and the U. S. Bureau of the Census has just recently estimated a population of 220 million—a growth of 50 million in the next 17 years.

Nearly 200 million of our 1975 population will live in cities and suburban areas which are sewered or need to be sewered. The real explosive growth of about 40 million will take place in the fringe areas around urban communities. These metropolitan complexes will create some new problems of water supply and waste disposal and many of the type already occurring.

In becoming the greatest Nation on earth, the United States has also become the greatest user of water. In 1900, as our industrialization was getting under way, we were using an estimated 41 billion gallons of fresh water daily. In 1945, at the crest of industrial effort required by World War II, we were using what seemed the astronomical amount of 150-160 billion gallons per day. Yet in 1957, just 12 years later, we used an estimated 270 billion gallons of water daily. The portent for the future is shown in the generally accepted estimate that by 1975, just 17 short space-age years away, the daily fresh water use will be 450 billion gallons. A recently published study on future water use² indicates that by 1980 our total daily fresh water use will have soared to almost 600 billion gallons, more than twice the amount now being used.

2. D. R. Woodward, Thesis No. 143, Industrial College of the Armed Forces, 1957.

Water use for all purposes is increasing rapidly. Demands for water from public supplies are multiplying because of explosive population growth and development of higher and higher standards of living. Irrigation, which once was largely practiced west of the Mississippi, is increasing rapidly in the eastern states. Increasing automation in homes and industry is producing more and more leisure time for the American family. As leisure time increases so do the pressures on waters suitable for fishing, bathing, boating, and other recreation. The fast pace required for just living in tomorrow's world is going to make water an absolute necessity for relaxation and mental deceleration. Recreation is now one of the fastest growing industries and water recreation is the fastest growing segment.

An ever-increasing use of water for all purposes to serve our explosive national growth spells out a tremendous burden on our water resources. Since total precipitation each year remains about the same, our total water resource to serve all our needs remains relatively constant. The water resource problem the Nation faces, then, is how to make our constant water supply meet an increasing demand by making available the necessary quantity of water, of the necessary quality, where it is needed.

To fill rising needs in the past, water conservation and development projects were concerned almost entirely with quantity management. These projects involved construction of dams for storage and flood control, irrigation structures, and aqueducts to transport surplus waters to areas of shortage. Such projects have done much to increase the total volume of available water to meet growing needs. More attention is being given to increasing the total available quantity of water by studying the feasibility of such measures as saline water conversion, groundwater recharge, reduction of losses from evaporation and transpiration, artificial rain-making, and underground storage of surplus waters.

In recent years, however, a very significant change has been under way in the water resources conservation and development field. Increasing attention is being given to domestic and industrial water uses and low flow augmentation for stream sanitation in water resource development projects. This change is being brought about not only by the pressure of water demands and increasing needs for water pollution control but because of the approach towards the foreseeable limits of our capturable water resources. This means that our present and predicted population and economic growths have placed us in the situation where projects for municipal and industrial supplies will have higher priority in water resource development.

It is important to recognize, then, that the water resources conservation and development movement includes much more than water quantity management, although projects of this type will continue to make important contributions. The era has been entered where quality management projects have high priority in supplying our present and future water needs. If water resources are going to support the Nation's continued world leadership and the demands of the atomic and space challenges, adequate pollution control measures must be achieved and maintained. Although a great deal already has been accomplished through the years, much more remains to be done.

It is common knowledge that the ultimate water supply requirements of the country can be met only by using limited water resources over and over again. This can be done only if sound principles of water conservation are practiced. Aside from its very important health values, an objective of water pollution control is to provide for the safe reuse of water as it flows from one user to

the next. There is no more economical way of supplying large areas of the country with huge volumes of water of satisfactory quality than by controlling stream pollution. After all, the waterways of the Nation compose our natural distribution system which should be used to the fullest extent for the delivery of water of satisfactory quality to points of use.

From the beginning of the present century through the 1930's, the Public Health Service and the State Health Departments were primarily concerned with water pollution as one of the media responsible for transmission of enteric diseases. Efforts were also directed, but to a somewhat lesser extent, to elimination of nuisance conditions, protection of water supplies against tastes and odors, and protection of fish and wildlife against oxygen deficiencies and toxic substances.

In meeting the health challenges of pollution, Federal and State health agencies have thus far been fairly successful, and since no major outbreak of waterborne disease has occurred in recent years, this country's leadership in the quality control of public water supplies is undisputed. Until World War II, the science of water and waste treatment and measurement of stream behavior characteristics were able to keep pollution at least within livable limits, if not always within desirable limits.

Progress in pollution abatement has been outdistanced by the speed of industrial and technical progress and the consequent problems. In the past the problems have been largely with bacterial pollution, natural organics, and chemicals of known toxicity and behavior. Although still concerned with the living organisms that cause waterborne diseases, engineers are becoming increasingly concerned with non-living contaminants in relation to health, and with the need to place greater emphasis on quality requirements for all water uses. These new concerns result from the explosive population and industrial growth, amazing new chemical technology, and certain prospects of widespread commercial uses of nuclear energy.

The health aspects of the impending sewage pollution load increases are serious as this means reductions in the safety factor of the bacteriological quality of surface waters for public supplies and recreational purposes. While the bacteriological quality of our streams is being still further degraded, many millions more of our people will have to depend on these surface waters for domestic and recreational uses.

Industry is experiencing a phenomenal expansion and in the next 17 years production will be almost double today's already high rates. In expanding, industry will be using larger quantities of process water and seeking ever more. Since a large part of this expansion is expected to be in the so-called wet-process industries, our water resources will be subjected to even greater amounts of industrial wastes. The increases in industrial wastes, together with the increases in municipal wastes, will make more complex the problems of maintaining suitable quality of surface waters for public and industrial supplies, and for recreational, wild life, and agricultural uses.

Since 1945 production in the chemical industry has grown immensely, especially in the manufacture of synthetic and petro chemicals. Each year increasing millions of pounds of synthetic detergents, insecticides, herbicides, and similar products for domestic use find their way into surface waters—either from the household sewer or from surface water runoff. Here is a new threat since in these cases it is the manufactured product that is contributing to stream pollution rather than the wastes from its manufacture.

Both product and waste resulting from the manufacture of thousands of new synthetics are of extremely complex composition. There is much need to know a great deal more about them as pollutants, although it is known that most are very stable and persistent in water while many are not affected, or little so, by present water and waste treatment methods. Most significantly, little is known concerning the long-term chronic effects on human beings from ingestion of these wastes, as toxicological techniques for such wastes in water are very deficient. It is known that the concentration of these chemicals at our water supply intakes is increasing steadily.

The growing use of radioactive materials is adding another new contaminant to our already complex pollution problems. The milling of uranium ores is already causing concern for some waters. The first privately-owned nuclear energy power plant is in operation and others will follow. Use of nuclear energy by other segments of industry will increase by leaps and bounds in the immediate years ahead. Water pollution problems resulting from use of radioactive materials will, of course, have serious health-related aspects.

Up to this point only a delineation of the problems has been presented. While the impact on our economy and standard of living is reasonably apparent, the consequence of much of this on man's environment is not so readily apparent and, as yet, certainly is less clearly defined and understood. In meeting the challenge of water pollution, there is a tough job ahead which is being approached with outdated methodology and at a pace far short of what present day trends dictate. It must be recognized that in the past most dealings have been with natural organics, with bacterial pollution, and with chemicals of known toxicity and behavior. Today the problem broadens out to include new types of contaminants associated with our chemical and atomic age.

Perhaps the greatest single need in this field today is to close the gaps in scientific knowledge with respect to the behavior of these new contaminants in streams, their relationships to natural stream purification phenomena and their effects, singularly and in combination, on aquatic life and on the people. This new knowledge must be translated rapidly into changes in waste treatment and water purification processes. At some point on our growth curve, the question of toxicity of water contaminants will have priority over the old question of typhoid. Presently, the concern largely is a potential one—so expressed because of our lack of knowledge of just what impact this build-up of total conglomerates has on our health and well-being—and on all water uses.

The question remains: How can research effort in water pollution be marshalled to produce the scientific intelligence so desperately needed? Universities, State and interstate agencies are uniquely qualified to make greater contributions. They already have close working relationships with industry, municipalities, equipment manufacturers, and consulting engineers. They have the distinct advantage of knowing local conditions. The problems should be defined so that universities, colleges, private and industrial research agencies, and individuals might better understand the needs. Then these agencies should emphasize research on problems of particular concern in the State, Region, and Nation.

Research in this area of health and water conservation and the application of the results requires a greater number of epidemiologists, chemists, biologists, sanitary engineers, and others. Additionally, help must come from

some of the relatively new disciplines such as the nuclear physicists. The current and foreseeable future shortage of engineering and scientific personnel is well known to all, and if the engineering profession is to catch up and keep pace with our complex water pollution problems, the attraction of young engineering and scientific talent into this and other fields of sanitary engineering is a necessity. The educational institutions have increasingly great opportunities and responsibilities in the production and, perhaps to less degree, in the attraction of engineers and scientists to meet the manpower needs of environmental health. Likewise, the health and water pollution control agencies, municipalities, industries, and consulting engineers face challenges in attracting and retaining these types of personnel which are so vital to the protection of our health and resources.

Increased research grants to universities and other research centers by Government and private agencies will attract more of our research potential into the field. More fellowships would also result in a larger share of scarce scientific and engineering talent being attracted to the task of solving our increasingly complex environmental problems.

The agencies concerned with water pollution control should take full advantage of opportunities for specialized training in this field. These training programs not only should improve the technical proficiencies of persons engaged in water pollution control and provide more incentive for men to remain in the field—they should provide an effective means of accelerating the transfer of research findings to practical use.

To meet these and other challenges in the control of water pollution, Congress has made it clear that primary responsibility rests with the States. Despite the progress which has been made in controlling water pollution, many State agencies have been inadequately supported by appropriations and otherwise need assistance to enable most effective programs throughout the Nation. Congress, therefore, has provided Federal assistance to strengthen State programs through financial aid, research, training, interstate enforcement, and other means to improve water quality management.

This cooperative approach is not unique in the Public Health Service. It has been the basic philosophy of the Service in its numerous programs to assist the States in their public health work. Even with the utmost cooperation among the agencies concerned, the job of water pollution control that lies ahead is extremely challenging. To get this job done requires the participation and support of all water users—municipalities, industries, sportsmen, conservationists, and the people.

In summary the problem can be summed up by a quotation of the Chief of the Fish and Game Commission of the State of Missouri:

"Approximately three-fourths of the earth's surface is water, one-fourth land. I contend that the Lord made the earth that way because that is the relative importance of the two. Regardless of what anyone may believe, however, the fact remains that life on this earth, in all its form and facets, has developed and must live accordingly.

"Water is our most important resource. The available supply of fresh, pure water is an absolute deadline beyond which no community, state or nation can ever go. When humanity runs out of clean water everything stops—that is the end of the road for man and all his activities."

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RADIOACTIVE POLLUTANTS

Progress Report of Task Force VI of the Committee on Atmospheric
Pollution of the Sanitary Engineering Division

PREFACE

The Sanitary Engineering Division Committee on Atmospheric Pollution has been engaged in the development of a comprehensive report on engineering management of the air resource. The authors are members of one of its task force groups—that on Radioactive Pollutants.

The Committee believes that sanitary engineers should be cognizant of the extent of the hazards that are being introduced as a result of the expanding use of radioactive tracers, prospective use of atomic energy as a source of power, and the increase in airborne radioactive dusts.

Water supply, food supply, and human exposures are matters of concern. Some of the difficulties of waste disposal and engineering measures that may be employed in safeguarding the air resource are previewed in this paper.

INTRODUCTION

Atomic energy has introduced a new potential hazard to public health. Fundamentally, atomic energy involves transmutation of elements with accompanying production of heat or other forms of energy. Radioactivity is a natural part product of atomic processes. Radioactive isotopes produced may be valued for themselves, or they may be an undesirable by-product. Radioactive elements may be present as solids, liquids, or gases. In any case, their presence can introduce a new man-made hazard to the environment. Compared to other contaminants, radioactive contaminants have three uniquely important features; (1), the radioactivity is indestructible; (2), the danger to man's health on a weight basis, with a few exceptions, is thousands of times as great as the danger from non-radioactive materials; (3), radioactivity cannot be perceived by any of man's five senses. Considering these features, it is obvious that measuring and controlling radioactive materials is important and difficult.

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Radioactivity in the air, in some respects, may be considered to be similar to any other toxic airborne material. There are definite toxic effects of air radioactivity just as there are toxic effects of lead, mercury, beryllium, carbon monoxide, hydrogen sulfide, war gases, and many other agents. Toxicologists refer to the exposure to these materials, excluding radiation, in mass or volume of contaminants per unit volume of air. In referring to radioactivity and radioactive exposures, the conventional units of measurement are expressed in curies, roentgens, rems, or rads.

Exposure to radioactivity in air can be both external and internal. External radiation would be caused by radiations emitted by particulates after they have deposited on various surfaces, such as ground, roofs, clothing, and exposed areas of the body, and from radiations of the unsettled airborne material. Internal exposure can be brought about by ingestion, inhalation, and absorption of radioactive particles or gases. Absorption would be through open wounds or sores on the body.

Governmental agencies (Manhattan Project, Atomic Energy Commission) have been concerned with the air radioactivity problem since the start of the atomic project in 1941. Much effort has been expended in the field of "health physics." Government research has provided material for the establishment of maximum permissible concentrations (MPC's) of various airborne radioactive pollutants by the National Committee on Radiation Protection and Measurement. This gives the engineer a definite isotopic standard to judge whether or not a given situation is a danger to public health, provided that satisfactory measurements can be made over a reasonable period of time.

The logical place to begin thinking of radioactivity in the air, excluding natural radioactivity, is at the origin of the contaminants. Atomic reactors and chemical processing plants, uranium ore mining and milling facilities, research laboratories using radiotracers, and other installations will be concerned with radioactivity in the air since processes utilized by these groups may result in release of airborne radioactivity. Grouping these together in one category, we shall refer to them as the in-plant, or occupational group.

In-plant personnel can and must be protected to the highest degree possible from particulates and gases. This will entail control of dusts and gases in containers and providing general ventilation, adequate hood facilities, pre-air treatment and disposal methods, and an emergency plan or system in the event of failure of one of the above.

Obviously, to insure protection of personnel, concentration of the airborne radioactivity must be measured. Unfortunately, this is not easily done. The MPC's are extremely low concentrations. Generally, it is virtually impossible to measure such low concentrations directly and instantaneously. Resort must be made to collecting devices which concentrate the activity from a large volume of air into a small volume of filter paper or liquid absorber. Hence, information on the efficiency of the counter device used to determine radioactivity of the collected sample must be estimated.

Fortunately, the instantaneous detection of airborne radioactivity values exceeding the MPC, although very desirable, is probably not critical as far as community-wide, or environmental air contamination is concerned. It is anticipated that the air contamination resulting from atomic energy operations, isotope use, etc., will be of a chronic nature with slow increases occurring as more installations get into operation. Also, short-time exposure of the population to concentrations exceeding the MPC would not be serious, since the limits are set for continuous, year-around exposures.

Disposing of airborne radioactivity poses a problem. Radioactive effluents generally cannot be dispersed directly in the air. Air cleaning systems ordinarily must be used. As a general rule, ordinary industrial filters are not satisfactory for cleaning the air of radioactive particles. Most industrial filters, cyclones, scrubbers, etc., are not very efficient for particles under one micron diameter. Due to the low MPC's for radioactive materials, special filters or air cleaning devices must be used where moderate or high levels of activity are expected. Radioactive rare gases, argon, xenon, krypton, are produced in nuclear reactors. These give rise to unique problems, since it is extremely difficult economically to remove these gases from an air stream. Fortunately, this production is relatively small volumetrically. A design engineer, making calculations for an air disposal system, should be guided by the maximum permissible concentrations of radioisotopes in air.

Maximum Permissible Concentrations

Two groupings are made when discussing maximum permissible concentrations of air radioactivity. These are the in-plant or occupational situation and the environmental situation. The occupational situation refers to persons normally exposed to radiation in the pursuance of their occupation, whereas the environmental situation refers to persons who are not normally exposed to radiation in excess of background. In occupational exposure, the exposure is subject to control, the exposures can be measured and limited, and persons suspected of receiving an overexposure can be excluded from areas of radiation. In comparing this with environmental exposure, there is usually no control of the exposure, measurement of the exposure is very difficult and, in some cases, may be even impossible. A person usually has no means of being excluded from environmental radiation exposure. For these reasons and genetic and age factors there is a difference in the permissible in-plant, or occupational, exposure and the permissible out-plant, or environmental exposure.

Table of permissible in-plant exposures are given in the National Bureau of Standards Handbooks^(1,2) 52 and 61. For environmental exposure, the situation of most interest to public health officials, the permissible concentrations of radioactive contaminants in air are 10^{-9} microcuries per milliliter for unknown beta or gamma emitters and 5×10^{-12} microcuries per milliliter for alpha emitters. For single isotopes, the maximum permissible concentrations are individually derived. A mixture of isotopes should have its individual isotopic concentrations reduced *pro rata* in order not to exceed the total maximum permissible concentrations. These concentration levels in Handbook 52 are taken in excess of background radiation. Because of recent increases in environmental background, reductions in the National Committee on Radiation Protection's recommendations of maximum permissible concentrations, or inclusion of background, may become effective in the future.

On January 8, 1957, the NCRP issued a policy statement which, in effect, modifies some of the maximum permissible radiation exposures to man which appeared in earlier handbooks. Briefly, it provides that in controlled areas the maximum permissible radiation levels should conform to certain general principles which are also applicable to external radiation exposures. These generally would reduce the maximum permissible concentrations of radio-nuclides in air and water to $1/3$ the values heretofore specified for radiation

workers where the critical organ involved is either the gonad or the whole body. Specifically, it would apply to Tritium, Sodium-²⁴, Xenon-135, etc., but would not apply to Iodine-131 or Strontium-⁹⁰, because, where single organs other than the gonads are regarded as the critical organ, the maximum permissible concentrations will continue, and for individuals outside of the controlled areas the maximum permissible concentrations should be 1/10 of those for occupational exposures.

When planning on the utilization of an air disposal system for radioactivity, attention should be given to all industries in the locale which might be emitting radioactive effluents to the air. Thought should also be given to the possibility of reducing the concentrations to allow for other industries locating in the same area and for legal changes in maximum permissible levels in the future. The demography, meteorology, and topography of the community in which the plant is located are factors that require thoughtful consideration.

Some situations may require restrictions not only on the maximum permissible concentrations of radioisotopes in air, but also on the total quantity of radioactivity which can be disposed into the air. The total quantity of radioactivity should be based on the process utilized and the size of the operation producing radioactivity, as well as upon maximum permissible levels. The total quantities of permissible radioactivity will not be found in the listing of maximum permissible concentrations but must be determined from design, environmental, and economic data. These precautions are exercised to aid in preventing the disposal of undue quantities of radioactivity which may be out of proportion to the economic contribution of a given installation. Few other generalizations can be made because each individual case will have to be determined on its own merits.

Municipalities now regulate the amount of particulate matter, etc., that can be discharged from stacks. Regulations in some instances should be made to govern the emission of radioactive gases and particulates. Several states have already adopted regulations embodying the technical recommendations of Handbook 61.

Air Survey Methods and Instruments

The primary purpose of an air survey is to show whether or not the air is safe to breathe. If an instrument over a reasonable period of time or reasonably projected over a period of time shows that the air activity is below the MPC, the air is considered safe to breathe. If activity is above the MPC, steps must be taken to correct the condition causing the air radioactivity. Any air activity above normal fluctuations in background is, of course, undesirable; when this is observed, an attempt to locate the source of activity is indicated.

If the radionuclides responsible for the air activity are unknown, then it can be categorically stated that no instrument exists which will tell the operator immediately, or within a few minutes, whether or not the air activity exceeds the MPC. This would be a very discouraging situation except for an alleviating factor. This is that concentrations exceeding the MPC by factors of 100 or 1000 can usually be detected within a few minutes. Personnel can then leave the area, without getting more than a few days' dose, and corrective action taken.

Even when the radionuclide is known, it can be difficult to measure at MPC levels in a few minutes, and difficult in some cases to measure rapidly 100 - 1000 times the MPC levels of unknown radionuclides. The reasons for the difficulty are (1) the extremely low magnitude of MPC's for radionuclides such as Pu-239, Ra-226, Po-210, Sr-90, γ -90 etc., (2) difficulties in converting instrument response into microcuries per cubic centimeter, and (3) interference from natural or less hazardous artificial nuclides. Even if it were possible to measure MPC levels very rapidly, there would still be the question as to whether or not the air measured by the instrument was representative of the air inhaled by the persons exposed. Further, concentration must exist over a specified period of time before it can be scientifically compared with the MPC's in the handbooks. Superficially there appear to be three ways of measuring air contamination. The first is simply to point a shielded detector at the sky. By "shielded" it is meant that the detector does not receive radiation from objects or liquid surfaces on the ground. The second method is to introduce the air directly into the measuring instrument. The third method is to absorb and concentrate the radioactivity into a liquid or solid medium whose activity is subsequently assayed. All three methods can be made to give continuous readings of air activity.

The first method, pointing the detector at the sky, has the very important advantage of simplicity, but lacks sensitivity. Very few if any present day instruments are designed for this purpose. At best this method would only be a qualitative indicator of gross changes of concentration and radioactive air masses.

In the second and third methods, the physical and chemical nature of the air activity must be considered. As explained in the following section "Air Cleaning Devices", air contamination can exist as particulate matter, reactive gases and non-reactive gases. This has an important bearing on the use of the second and third methods.

We consider now the second method, introduction of the air directly into the detecting instrument. Such instruments are commonly of two types, the "flow ion chamber" and the jacketed GM tube. The flow ion chamber measures air ionization produced by the radioactive contaminant as it flows through the device. It is capable of high sensitivity, detects alpha and weak beta radiations, and in some cases, can measure almost instantaneously concentrations near the MPC level.^(4,5) The thin wall jacketed GM tube⁽⁶⁾ is also valuable, and usually cheaper than the flow ion chamber. Because of the wall, however, it cannot be used for weak beta or alpha emitting contaminants. Again, for certain radionuclides, the jacketed GM tube can measure concentrations near the MPC level rather rapidly.

The big disadvantage of the second method, introduction of the radioactive air into the detector, is that the instruments used are subject to surface contamination. If the air contaminant is in the particulate form, or present as a reactive gas, a deposit of radioactivity will build up on the surfaces of the instrument. High background radiation due to this cause may render the device useless or nearly so.

For monitoring non-reactive radioactive gases, however, the flow-ion chamber and the jacketed GM tube are uniquely valuable. Such non-reactive gases, because of their inertness (krypton, xenon, argon, etc.) are very difficult to absorb; no other method is practical.

The third method, concentration of the air activity into an absorbing medium with subsequent radioassay, is by far the predominant method at the

present time. It is applicable to every type of air contamination except that due to non-reactive gases, which may be measured as just described. Reactive gases are collected by a liquid absorbing reagent which is specific for the gas in question; for example, NaOH solutions are used⁽⁷⁾ to absorb I-131. After absorption, an aliquot of the liquid is usually evaporated and activity of the solid concentrated sample determined.

Particulate matter is usually collected with dry mechanical filters. Numerous other methods of collecting particulate matter are available, such as electrostatic precipitators, dry or wet impingement, fall-out trays, etc. However, filters are preferred⁽⁸⁾ for almost all applications.

One of the best filter papers available today is the so-called "Millipore" filter.⁽⁹⁾ This paper has virtually 100% filtration efficiency for particles in all size ranges down to 0.1 micron diameter or less. Although, as pointed out by Schulte,⁽¹⁰⁾ high efficiency is not needed for all air sampling purposes, uniform high efficiency for all size ranges is very desirable. The Millipore filter has a definite advantage for use in collecting particulate alpha and weak beta emitters. Some of these radiations have a very short range in solid materials, of the order of 100 microns or less. The Millipore filter collects particles on its surface, in contrast to other papers in which the particles penetrate the surface; this prevents some of the activity from being detected by the counting instrument. Consequently, when using papers other than the Millipore, corrections must be applied to account for absorption of the weak radiations in the paper itself.

After collection of the activity from the air, a radioassay of activity is made. It would be desirable at this point to know size distributions of the collected radioactive particulate material, since retention of particles in the human respiratory system is very much a function of particle size. Unfortunately, techniques of this type of analysis have had very little development. A better approach to the problem from a physiological standpoint would be to design the air sampling instrument so that particles are separated into various size ranges before collection. Burnett and Hatch⁽¹¹⁾ consider the radio-particulate problem in detail.

The radioassay is concerned principally with determination of the gross activity of the sample. It is desirable, of course, to determine what radio-nuclide or nuclides are responsible for the activity; however, this is usually impossible due to the low level of activity collected. In some cases, the rate of activity decay of the sample, or absorption measurements, can give information on the type of air activity collected. The solubility or non-solubility of the particle in body fluids is also of interest.

No detailed discussion can be given here of the large subject of radioassay and radioactivity measurement. For measuring the activity of air samples contained on filter papers, etc., some of the most useful techniques involve the use of either (1) photographic film, (2) thin window GM counters with scalars, (3) gas flow proportional counters, or (4) scintillation counters.

Continuous air monitors, which can be made to activate an alarm when the contamination exceeds a certain level, are of course very valuable. Kuper, Foster and Bernstein⁽¹²⁾ describe a continuous monitor for both beta-gamma and alpha emitting dust. D. J. Knowles⁽¹³⁾ has designed a monitor for airborne alpha emitters. H. V. Watts and others⁽¹⁴⁾ have developed a continuous monitor which uses both GM and scintillation counters. At Oak Ridge National Laboratory, and other installations, continuous air monitors, with alarms, are

in routine use. Several models are available commercially,⁽¹⁵⁾ but most are rather expensive, costing several thousand dollars.

In conclusion, it may be stated that the technique of measuring air contamination is sufficiently difficult and complicated that personnel with training in health physics and air analysis should be available to handle the problem where more than tracer levels of activity are used.

Air Cleaning Devices

A knowledge of air cleaning devices for radioactive contaminants is of importance to the public health engineer for several reasons. He may be called on to recommend devices for cleaning ventilating air from industrial or government laboratories. He may be asked to recommend corrective measures to industrial plants discharging objectionable quantities of airborne radioactivity.

As pointed out by Silverman,⁽¹⁶⁾ air cleaning for radioactive contaminants differs from general cleaning processes in two major respects. One is the high order of toxicity of the contaminants; the second is the accumulation of radioactivity in the cleaning device. This may pose health problems both in external radiation and in subsequent disposal of the radioactivity.

A most important factor affecting the performance of air cleaning equipment is the particle size of the contaminant to be removed. The difference in the aerodynamic behavior of a particle 100 microns in diameter and one of 0.01 microns diameter is enormous. A particle of 100 microns diameter settles very rapidly under gravity (60 ft./min.) and is readily removed from an air stream by centrifugal force. The 0.01 micron particle has a negligible gravity settling rate, (10^{-3} ft./min.) and, from a practical standpoint, it is impossible to remove particles of this size by centrifugal force fields. However, very small particles exhibit a "Brownian" motion due to impacts of gas molecules on the particles. Removal of very small particles in mechanical filters is due almost entirely to this effect.

The distinction between "particulate" and "gaseous" contamination has not been clearly defined. Radioactive contaminants can exist in the air in various states of aggregation, from single molecules to aggregates over one millimeter in diameter consisting of billions of molecules. Undoubtedly, dispersions of single molecules in air are gaseous contamination; but dispersions of "particulate matter" consisting of clusters of 2-100 molecules are in a doubtful region. Such a dispersion would behave as a gas in all essential respects, yet would not be considered a gas in the strict sense of the word.

The next most important factor affecting air cleaning efficiency is the rate of air flow through the device. The effect of air flow rate depends on the particle size of the contaminant to be removed. Collection of "large" particles of 100 microns diameter and over is assisted by increasing air flow rate in the case of cyclone separators, and in some types of mechanical filters. These devices depend mainly on centrifugal action to throw out large particles on collecting surfaces; increased flow rates increase the centrifugal action, which throws out the particles more effectively. "Small" particles under 0.01 micron diameter are virtually immune to centrifugal force and decreasing flow rates assist in collection. Low flow rates assist also in the absorption of gases by charcoal, etc.

High Efficiency Filters for Particulate Contamination

As mentioned previously, high efficiency collecting devices are needed because of the high toxicity of radioactive materials. However, there are cases where the amount, specific activity, and particle size of the contaminant is such that ordinary industrial filters will suffice.

In general, the use of cyclone separators is entirely unsatisfactory. Likewise, ordinary air conditioner filters, furnace filters, etc. are extremely inefficient for collecting particles under 1 micron diameter; many commercial filters of this type have efficiencies of 10-20% or under.

The most common type of filter that has been used for radiological filtration is a dry asbestos-cellulose type filter, originally developed by the Chemical Corps for purifying air of toxic aerosols. Silverman⁽¹⁶⁾ gives a description of the filter and later designs using an all glass media instead of cellulose asbestos. These filters will handle air at 250 ft./min. face velocity, at a pressure drop of 1 to 2 inches water. The efficiency is 99.95-99.99% for particles under 1 micron diameter. All-glass filters are preferred, since they are less subject to corrosion, do not present a fire hazard, and are usable at higher temperatures.

Electrostatic precipitators have met with little enthusiasm. Their first cost is very high compared to the filters described above; the presence of highly ionizing radioactivity has been postulated as a cause of breakdown and arcing within the device. Bralove⁽¹⁷⁾ discusses the advantages and disadvantages of the electrostatic precipitator.

The ultimate high efficiency filter is one which has a high, known efficiency for all particles from molecular dimensions to particles 1 mm. in diameter. No manufacturer publishes such information. Recent work⁽¹⁸⁾ has shown, however, that it is possible to obtain almost any desired degree of protection with the use of mechanical filters. This is due to the establishment of an "aerosol size for maximum penetration". This critical size is a function of the type filter and air flow rate. Larger and smaller particles than those of this critical size penetrate the filter less readily; hence, if this size is known, it is merely necessary to place filters in series to obtain the desired degree of protection, calculating the minimum efficiency at the critical size. Assurance will be had that the performance on all other sizes will be better. Unfortunately, sufficient information on the critical size as a function of filter type and flow rate is not yet available.

Radioactivity Accumulation in Particulate Filters

This problem has two aspects; radiation hazards, and disposal⁽¹⁹⁾ of the filters. Usually filters will be installed in overhead attics, duct lines, separate buildings, etc., and will not cause external radiation hazards during normal operation. When the filter is to be replaced due to the development of excessive pressure drop, two radiation hazards may be present; (1), excessive external radiation, (2) the possibility of re-dispersal of radioactive dust due to moving and jarring the filters. The external radiation hazard ordinarily will not be serious for installations using millicurie quantities of radioisotopes, particularly if the isotopes used in the installation are mainly pure beta emitters such as carbon-14 and phosphorus³².

The extent of the dust re-dispersal problem depends on the nature of the dust collected. "Atmospheric dust", which is usually the main constituent of the collected contaminants, sticks well to any surface because of its high

surface to mass ratio. In any case, it is advisable to wet down the filter with water, or spray it with lacquer, to retain the dust on the filter body. The use of gas masks is indicated where appreciable amounts of radioactivity have been collected, in addition to routine health physics precautions. Used filters must be disposed of in accordance with regulations established for solid wastes. If the filters are very highly contaminated, it may be necessary to return them to an AEC facility for final disposal.

Gas Cleaning Problems

Radioactive gases may be divided into two classes; the gases which are not readily absorbed on surfaces, which we may designate as non-reactive, and the reactive gases. The principal non-reactive gases are $C^{14}O_2$, H_2^3 , A, Kr and Xe. Reactive gases of most interest are elemental I-131, and compounds of C-14, I-131, P-32, and S-35. Reactive gases may be removed from an air stream by more or less conventional methods: activated charcoal, scrubbing towers, etc. Perhaps the most important gaseous contaminant is elemental I-131. This isotope has a high yield in fission, has a very high toxicity, and a reasonably long half life of 13 days. A special gas scrubbing tower, packed with silver nitrate coated "saddles", has been developed to handle this problem.

Non-reactive gases present a difficult air cleaning problem, particularly the noble gases A, Kr, and Xe. At the present time, it is virtually impossible to clean these gases economically from large quantities of air. Two approaches to the problem have been used. One is to keep all effluents containing these gases to a very small volume, where those with a short half-life can decay. The gaseous effluent is passed through activated charcoal at very low temperatures, which "holds up" the gases long enough to permit most of the activity to decay out. A variant of this method is to compress and store the gases. The other approach has been to rely on atmospheric dilution. Since toxicity of these gases is very low compared to most radioactive gases, this method is satisfactory in some cases. Caution will have to be exercised in the future, however, in the use of the dilution method. Some of the noble gases, particularly krypton-85, have long half-lives, and a too widespread use of this method could result in a measurable increase in the radioactivity of the entire atmosphere of the earth.

CONCLUSIONS

A distinction must be made between nuclear reactor installations and installations using radioisotopes only as tracers. In the first case, it is obviously necessary to insist on well-engineered air cleaning systems. In the second case, the requirements are simpler. If the isotopes are to be used in non-volatile forms, then the specification of a high efficiency filter as described herein should be sufficient. If gas-phase processing is involved, then activated charcoal filters are also required. Charcoal filters are adequate for almost all gases, but are not effective in removing CO_2 , CO, H_2 , NH_3 , and a few other gases. If the presence of these gases in fairly large quantities is expected, special gas absorption devices may be necessary. The decision

on what equipment to use will be dependent on the isotope, the quantity of activity, the amount of dilution supplied by the stacks, and other factors.

Respectfully submitted,

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PROCEEDINGS PAPERS

The technical papers published in the past year are identified by number below. Technical-division sponsorship is indicated by an abbreviation at the end of each Paper Number, the symbols referring to: Air Transport (AT), City Planning (CP), Construction (CO), Engineering Mechanics (EM), Highway (HW), Hydraulics (HY), Irrigation and Drainage (IR), Pipeline (PL), Power (PO), Sanitary Engineering (SA), Soil Mechanics and Foundations (SM), Structural (ST), Surveying and Mapping (SU), and Waterways and Harbors (WW), divisions. Papers sponsored by the Department of Conditions of Practice are identified by the symbols (PP). For titles and order coupons, refer to the appropriate issue of "Civil Engineering." Beginning with Volume 82 (January 1956) papers were published in Journals of the various Technical Divisions. To locate papers in the Journals, the symbols after the paper number are followed by a numeral designating the issue of a particular Journal in which the paper appeared. For example, Paper 1859 is identified as 1859 (HY 7) which indicates that the paper is contained in the seventh issue of the Journal of the Hydraulics Division during 1958.

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- AUGUST: 1725(HY4), 1726(HY4), 1727(SM3), 1728(SM3), 1729(SM3), 1730(SM3), 1731(SM3), 1732(SM3), 1733(PO4), 1734(PO4), 1735(PO4), 1736(PO4), 1737(PO4), 1738(PO4), 1739(PO4), 1740(PO4), 1741(PO4), 1742(PO4), 1743(PO4), 1744(PO4), 1745(PO4), 1746(PO4), 1747(PO4), 1748(PO4), 1749(PO4).
- SEPTEMBER: 1750(IR3), 1751(IR3), 1752(IR3), 1753(IR3), 1754(IR3), 1755(ST5), 1756(ST5), 1757(ST5), 1758(ST5), 1759(ST5), 1760(ST5), 1761(ST5), 1762(ST5), 1763(ST5), 1764(ST5), 1765(WW4), 1766(WW4), 1767(WW4), 1768(WW4), 1769(WW4), 1770(WW4), 1771(WW4), 1772(WW4), 1773(WW4), 1774(IR3), 1775(IR3), 1776(SA5), 1777(SA5), 1778(SA5), 1779(SA5), 1780(SA5), 1781(WW4), 1782(SA5), 1783(SA5), 1784(IR3)^c, 1785(WW4)^c, 1786(SA5)^c, 1787(ST5)^c, 1788(IR3), 1789(WW4).
- OCTOBER: 1790(EM4), 1791(EM4), 1792(EM4), 1793(EM4), 1794(EM4), 1795(HW3), 1796(HW3), 1797(HW3), 1798(HW3), 1799(HW3), 1800(HW3), 1801(HW3), 1802(HW3), 1803(HW3), 1804(HW3), 1805(HW3), 1806(HY5), 1807(HY5), 1808(HY5), 1809(HY5), 1810(HY5), 1811(HY5), 1812(SM4), 1813(SM4), 1814(ST6), 1815(ST6), 1816(ST6), 1817(ST6), 1818(ST6), 1819(ST6), 1820(ST6), 1821(ST6), 1822(EM4), 1823(PO5), 1824(SM4), 1825(SM4), 1826(SM4), 1827(ST6)^c, 1828(SM4)^c, 1829(HW3)^c, 1830(PO5)^c, 1831(EM4)^c, 1832(HY5)^c.
- NOVEMBER: 1833(HY6), 1834(HY6), 1835(SA6), 1836(ST7), 1837(ST7), 1838(ST7), 1839(ST7), 1840(ST7), 1841(ST7), 1842(SU3), 1843(SU3), 1844(SU3), 1845(SU3), 1846(SU3), 1847(SA6), 1848(SA6), 1849(SA6), 1850(SA6), 1851(SA6), 1852(SA6), 1853(SA6), 1854(ST7), 1855(SA6)^c, 1856(HY6)^c, 1857(ST7)^c, 1858(SU3)^c.
- DECEMBER: 1859(HY7), 1860(IR4), 1861(IR4), 1862(IR4), 1863(SM5), 1864(SM5), 1865(ST8), 1866(ST8), 1867(ST8), 1868(PP1), 1869(PP1), 1870(PP1), 1871(PP1), 1872(PP1), 1873(WW5), 1874(WW5), 1875(WW5), 1876(WW5), 1877(CP2), 1878(ST8), 1879(ST8), 1880(HY7)^c, 1881(SM5)^c, 1882(ST8)^c, 1883(PP1)^c, 1884(WW5)^c, 1885(CP2)^c, 1886(PO6), 1887(PO6), 1888(PO6), 1889(PO6), 1890(HY7), 1891(PP1).

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- JANUARY: 1892(AT1), 1893(AT1), 1894(EM1), 1895(EM1), 1896(EM1), 1897(EM1), 1898(EM1), 1899(HW1), 1900(HW1), 1901(HY1), 1902(HY1), 1903(HY1), 1904(HY1), 1905(PL1), 1906(PL1), 1907(PL1), 1908(PL1), 1909(ST1), 1910(ST1), 1911(ST1), 1912(ST1), 1913(ST1), 1914(ST1), 1915(ST1), 1916(AT1)^c, 1917(EM1)^c, 1918(HW1)^c, 1919(HY1)^c, 1920(PL1)^c, 1921(SA1)^c, 1922(ST1)^c, 1923(EM1), 1924(HW1), 1925(HW1), 1926(PL1), 1927(HW1), 1928(HW1), 1929(SA1), 1930(SA1), 1931(SA1), 1932(SA1).

c. Discussion of several papers, grouped by divisions.

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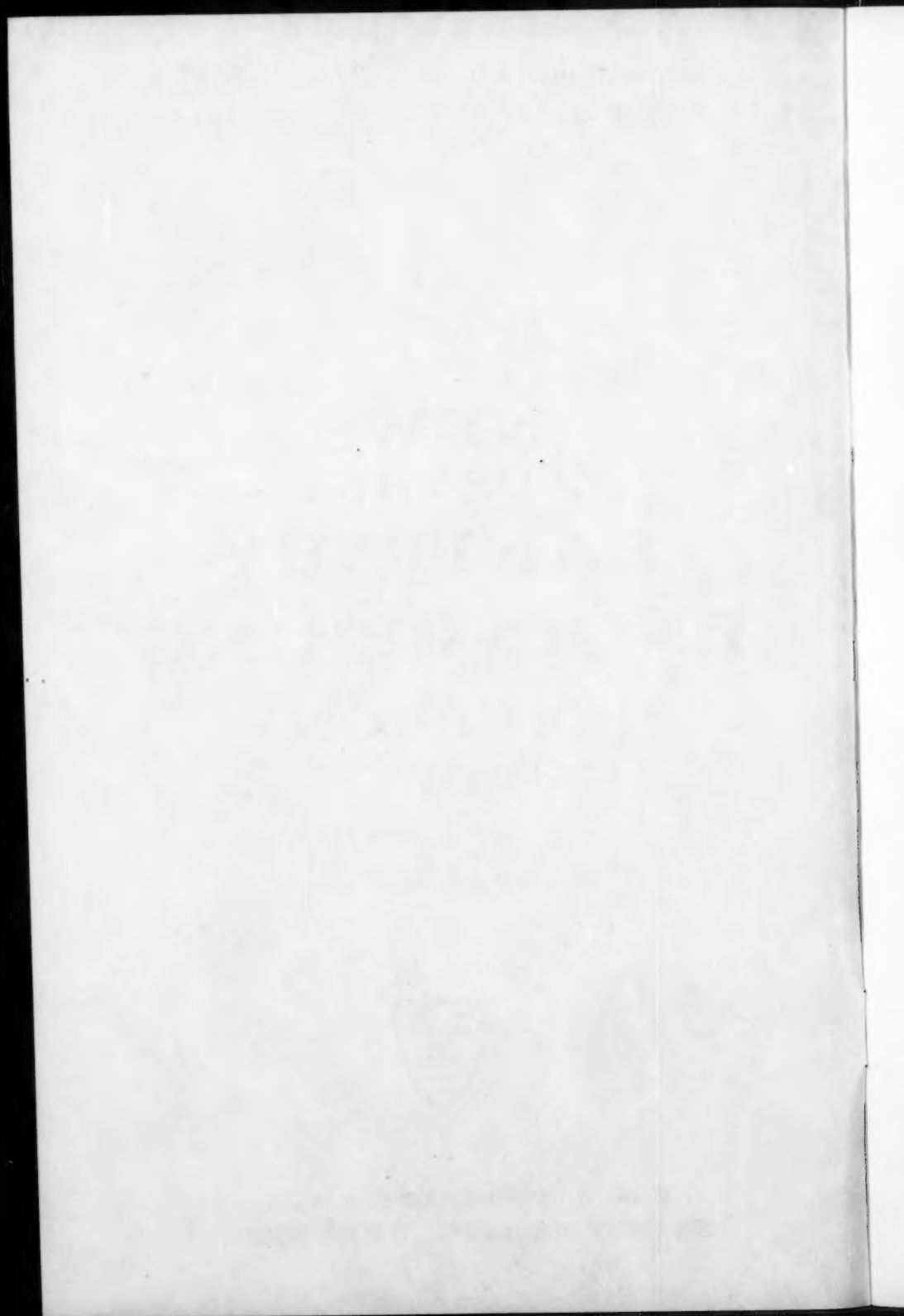
PART 2

Your attention is invited

**NEWS
OF THE
SANITARY
ENGINEERING
DIVISION
OF
ASCE**



**JOURNAL OF THE SANITARY ENGINEERING DIVISION
PROCEEDINGS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS**



DIVISION ACTIVITIES

SANITARY ENGINEERING DIVISION

Proceedings of the American Society of Civil Engineers

NEWS

A CHALLENGE TO YOU

Engineers in general and sanitary engineers in particular have been voicing increasing concern during the past few years about professional recognition. The United Engineering Center in New York City will provide a symbol of unity of the various branches of the engineering profession which can well lead to increasing unity of voice and action in the development of greater public awareness of the engineer's contribution to our society. The Member Gifts Campaign is now underway and all of us are being asked to contribute. Here is our challenge and opportunity. The success of the Campaign will determine whether we deserve the prestige we seek.

The October 20 issue of Engineering News-Record contained an outstanding editorial on the engineer's stake in the United Engineering Center. It is reprinted here in full through courtesy of the McGraw Hill Publishing Company. If you have not already read this you are invited to do so now.

"Professional Pride and Prestige Are at Stake

"Plans to build a new headquarters in New York City for the principal engineering societies of the United States are well advanced, with more than half of the necessary \$10 million already available or pledged. But this is not as good as it sounds, for still teetering on the brink of uncertainty is the truly crucial part of the program. This is the Member Gifts Campaign, just now getting underway, in which engineers are asked to dig down in their own pockets and support this significant undertaking.

"Although the results so far are encouraging, there remains a haunting doubt that engineers have yet sensed the importance of the outcome to themselves personally. For how well and how universally they support this United Engineering Center financing will be used by the world at large to measure how much pride U. S. engineers have in their profession. The prestige of engineering will go up or down according to the results, which cannot fail to affect the economic status and community standing of every engineer. The campaign for a new headquarters of engineering is thus not just another fund-raising drive, but a challenge to engineers to stand up and be counted.

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"As the campaign now stands there is another facet to the challenge that engineers cannot afford to overlook. Having asked and obtained the cooperation of industrial leaders to raise \$5 million of the total, engineers are in the position of seeing 70% of this total subscribed, while less than 15% of their commitment has been pledged. Moreover, this commitment is only \$3 million compared to industry's \$5 million, since \$2 million will be available from the sale of the present headquarters, which was a gift 50 years from Andrew Carnegie.

"EVERY ENGINEER should take a keen interest in the success of the UEC campaign, but it is of course the 180,000 members of the five major societies—Civils, Miners, Mechanicals, Electricals and Chemicals—who must bear the main responsibility since it is they who will own the new building and profit most directly from it. Actually each individual subscription would be extremely modest if every member could be counted on to do his share—less than \$20 per head, and with payment spread over three years if desired. But since universal support is never possible, engineers must be counted on to give according to their abilities, which vary according to the rewards that engineering has afforded them. Instead of \$20 some should give \$2,500, and others should give various amounts up and down the scale. The principal requirement is for every engineer to recognize his responsibility and act upon it.

"The pride and prestige that immediate financial support will insure will be enhanced for many years to come by the building itself. It will occupy a block-long site facing New York's United Nations Plaza—a world center attracting thousands of visitors every day. To them, the building's 20-story tower will symbolize engineering's importance. And inasmuch as the building will house not only the five societies that own it, but sixteen other engineering societies and organizations, it will also symbolize and promote the cause of unity in the profession, another prestige raiser.

"THESE PRIDE AND PRESTIGE FACTORS are in addition to the very tangible contribution that the building will make in improving operating efficiency of the headquarters staffs of the engineering societies. When the present building was built, they handled the affairs of 16,000 members. Now there are more than ten times that number. Moreover, when the present building was built, engineering served an economy measured by a gross national product of about \$35 billion; this year's figure will be \$435 billion. A headquarters building commensurate with this growth is obviously necessary for the service that engineering is expected to render.

"If engineering is more than a casual occupation—and statements to the contrary are seldom voiced—the new United Engineering Center, financed in substantial part by engineers themselves, will lend these claims real substance. Conversely, failure to support it can readily be taken by the world at large as an indication that engineers do not place as much stock in themselves and their profession as their frequent assertions would seem to imply.

"That such an opinion, were it to become common, would be damaging to the rising prestige of engineering can hardly be questioned. It is equally certain that such damaged prestige would inevitably have a

bad effect on the economic status and community standing of engineers. It is up to the engineers of the country, each acting individually, to see that this does not happen."

-Reprinted from Engineering News-Record,
October 30, 1958
McGraw-Hill Publishing Company,
Incorporated.

S.E.D. EXECUTIVE COMMITTEE MEETING

The Executive Committee of the Sanitary Engineering Division met in New York City on October 14 and 15, 1958. Excerpts of the minutes of this meeting of particular interest to Division members are:

Research

The Research Committee has met with the ASCE Research Committee and is now formed as an Administrative Committee and has proposed to the ASCE Research Committee several basic research problems and is hopeful of receiving grants in support of this work.

Water Supply

The purpose of the Water Supply Engineering Committee is to be rewritten and a new control group formed.

Atmospheric Pollution

The Chairman of the Committee on Atmospheric Pollution has completely reorganized the work of the Committee into a program of Engineering Management of the air resources and has set up numerous task forces; namely,

- A. The Status of Air Sanitation Activity
- B. Air Sanitation Engineering
- C. Education and Training
- D. Research Activities on Atmospheric Pollution and its Control
- E. Activities of Other Branches of Engineering Societies and Co-Related Associations
- F. Radioactive Pollutants
- G. Design and Guides to Design Practice
- H. Setting forth opportunities for Sanitary Engineers in an important area of environmental control.

The Executive Committee reworded the purpose of the Committee on Air Pollution as follows:

"To formulate a strong program of constructive activity and professional leadership in the field of engineering management of the air resource; to stimulate orderly presentation of technical materials for publication; to prepare and present information concerning engineering practices related to air resource management, including air sanitation and its relation to community environment; and to develop one or more manuals of practice on the subject as the need arises."

Manuals

The Manual of Practice on Sewage Treatment Plant Design Committee has galley proofs now out for corrections.

The Design and Construction of Sanitary and Storm Sewers Manual has been sent to the printers for galley proofs.

The Manual of Sanitary Practice on Sanitary Landfill has been reviewed and is now being corrected.

The Manual of Incineration Practice received considerable discussion and it was decided that the completed parts would be published in the Sanitary Engineering Journal for comments.

Sanitary Engineering Conference

A Sanitary Engineering Conference will be held in Cincinnati in January, 1960, by the Division. The first session will be devoted to the overall conference theme and will include outstanding national figures. The next three sessions will be devoted to Air Pollution, Water Pollution, and Land Pollution. In the final session a prominent leader in sanitary engineering will summarize the preceding sessions.

The Joint Committee and ASEIB

The following action was taken by the Executive Committee concerning the continuation of the Joint Committee for the Advancement of Sanitary Engineers:

"Whereas A.W.W.A. by resolution dated September 8, 1958 and F.S.I.W.A. by resolution dated October 9, 1958, have recommended that the Joint Committee for the Advancement of Sanitary Engineering be abolished.

"Whereas the support of these organizations is essential in carrying out the function and purposes of the Joint Committee.

"Now, Therefore, Executive Committee of S.E.D. recommends that A.S.C.E. withdraw its sponsorship of the Joint Committee for the Advancement of Sanitary Engineering and that S.E.D. extend its program to include the stated purpose of the Joint Committee: 'to advance the training and professional status of sanitary engineers'."

Division Officers for Year 1958-59

Ray Lawrence was elected Chairman and Lewis Young Vice Chairman. A. D. Caster was reappointed Secretary for the year of 1958-59 and David H. Howells was tentatively appointed Assistant Secretary of the Executive Committee to take over the duties of Secretary for the year of 1959-60.

DID YOU KNOW THAT

H. Loren Thompson of Portland, Oregon, has been named Oregon Engineer of the Year by the professional engineers of Oregon. He supervised the arrangements for the recent A.S.C.E. Convention in Portland.

The retirement of Mr. Earl Devendorf as Director of the Bureau of Environmental Sanitation for the New York State Department of Health has been announced by the State Health Commissioner. Mr. Devendorf has been with the New York State Health Department for more than 40 years and has served in his present position since 1948.

James G. Terrill, Jr., has been appointed a member of the WHO Expert Advisory Panel on Radiation. Membership on the Panel is an honorary appointment for a term of 5 years.

William H. Owen, Assistant Director of the Division of Sanitary Engineering of the Tennessee Department of Public Health has joined the firm of Barge, Waggoner & Sumner of Nashville as an associate member. Mr. Owen is an alumnus of Vanderbilt and Harvard Universities.

MONTHLY SCIENTIFIC PUBLICATION OF INTEREST TO DIVISION MEMBERS

The American Geophysical Union has announced that it is combining the scientific and technological material in its bimonthly Transactions with the quarterly Journal of Geophysical Research and will issue the Journal of Geophysical Research as a monthly publication starting in 1959. This will contain much information related to Hydrology of interest to members of the Sanitary Engineering Division.

The subscription rate for the new Journal is \$16.00 for the calendar year. Memberships, however, are invited. Membership is \$10.00 per year and includes a subscription to the Journal. Any who are interested should write to the office of the American Geophysical Union, 1515 Massachusetts Avenue, N. W., Washington 5, D. C.

* * *

"People are generally better persuaded by the reasons which they have themselves discovered than by those which have come into the mind of others."

-Blaise Pascal

* * *

SANITARY ENGINEERING EDUCATION

CHANGES IN SANITARY ENGINEERING AT THE UNIVERSITY OF TEXAS

Professor Gloyna of the University of Texas has revealed that extensive changes are taking place in sanitary engineering facilities at that institution.

Present plans for the sanitary engineering center at the University of Texas include two facilities. One of these will be located in the main campus in downtown Austin. This unit will be used primarily for instructional purposes, but will accommodate a limited number of research projects. This new building will be occupied during the fall of 1959, and will include the most modern equipment available. It will be built around four laboratories; microbiology, sanitary chemistry, radiation detection, and unit operations. These laboratories will be used for instructional work in both the undergraduate and graduate programs in sanitary chemistry, sanitary microbiology, air pollution, industrial waste treatment, and other related subjects. The laboratory system on the campus when complete will consist of about 6,000 square feet of instructional and office space.

The second part of the sanitary engineering center will be located at the University's Balcones Research Center. Its primary purpose is to facilitate

and provide a means for conducting larger research projects. Currently used laboratories at the Center include a chemistry laboratory, a radioactivity preparations room, a low-level radioactivity analysis room, a low-level counting room, and pilot plant facilities.

The sanitary engineering program at the University of Texas has been particularly fortunate in obtaining a very complete line of radiation detection equipment. Through a cooperative arrangement with the University of Texas, the Texas State Department of Health, and the Reactor Training Program of the Atomic Energy Commission, almost any type of radiation detection problem can be studied. Included in the list of equipment is a 256-RCL Gamma Spectrometer, a model 750 Baird-Atomics gas flow counter, an electrometer which will count either a radioactive gas or handle a 4-inch diameter planchet, a scanner for radio-chromatograms, personnel and dosage determination instruments, and routine counting instruments.

TRAINING COURSES AT THE ROBERT A. TAFT SANITARY ENGINEERING CENTER

The following courses are scheduled at the Robert A. Taft Sanitary Engineering Center:

March 2-13, 1959

Basic Radiological Health

March 2-13, 1959

Water Quality Management—Sanitary Engineering Aspects

March 16-25, 1959

Environmental Health Aspects of Nuclear Reactor Operations

March 16-20, 1959

Physical Analysis of Atmospheric Particulates

March 23-27, 1959

Analysis of Atmospheric Inorganics

May 4-15, 1959

Organic Industrial Wastes Characterization

May 4-15, 1959

Sanitary Engineering Aspects of Nuclear Energy

May 25-29, 1959

Shellfish Sanitation

May 25-29, 1959

Analysis of Atmospheric Organics

June 1-12, 1959

Advanced Training for Sanitary Engineer Reserve Officers: Water Quality Management—Sanitary Engineering Aspects

June 15-26, 1959

Advanced Training for Sanitary Engineer Reserve Officers: Community Air Pollution

These courses are intended for engineers and scientists actively engaged in the field of sanitary engineering who desire to obtain the latest techniques and newest developments in their areas of particular interest. Fundamental

information normally acquired at the undergraduate level is not usually included in the courses. A few broad, general courses are offered for those who have technical administrative positions and wish to acquire an over-all perspective in specific areas of sanitary engineering.

Admission is by formal written application. Applications and specific information pertaining to the various courses may be obtained from the Robert A. Taft Sanitary Engineering Center, 4676 Columbia Parkway, Cincinnati 26, Ohio.

EXPANSION OF AIR POLLUTION INSTRUCTION AT UNIVERSITY OF NORTH CAROLINA

The Department of Sanitary Engineering, School of Public Health, of the University of North Carolina has initiated a course plan in air pollution at the graduate level. This is incorporated into curricula leading to three degrees at the master's level; Master of Science in Sanitary Engineering, Master of Science in Public Health, and Master of Public Health, and for those who demonstrate capability is part of a plan for advanced study leading to the Doctor of Philosophy.

The Graduate Administrative Board of the University has established three new courses being offered this academic year in air hygiene and air pollution control under Dr. Lyman A. Ripperton. These courses are "Fundamentals of Air Hygiene," "Effects and Measurements of Air Pollution," and "Control of Air Pollution." These may be combined with courses in occupational health and industrial hygiene to prepare for professional development in those phases of environmental health. Laboratory facilities and equipment for student work and for individual research have been greatly increased.

Initiation of this program was made possible through a Community Air Pollution Training Grant to the University of North Carolina by the U. S. Public Health Service. These are graduate assistantships, traineeships, and staff positions available for qualified persons. Inquiries should be to Professor Emil T. Chanlett, Department of Sanitary Engineering, School of Public Health, University of North Carolina, Chapel Hill, North Carolina.

PAN AMERICAN SANITARY BUREAU SPONSORS LECTURES IN RADIOLOGICAL HEALTH

Dr. Dade W. Moeller (J.M. ASCE), Mr. Peter J. Valaer, and Mr. Don Geilker, of the Robert A. Taft Sanitary Engineering Center participated in a course on the "Public Health Aspects of Radiation," conducted at the School of Tropical Medicine, San Juan, Puerto Rico on October 7-15, 1958. The course, under sponsorship of the Pan American Sanitary Bureau, was attended by representatives of 13 Latin American countries and Puerto Rico. Through a system of simultaneous translation, trainees were permitted to listen to the lectures in either Spanish or English.

Moeller, who is Chief of the Center's Radiological Health Training Section, also presented a series of lectures at the School of Sanitary Engineering, National University of Mexico, and to the Department of Sanitary Works of the Ministry of Hydraulic Resources on problems related to water monitoring and radioactive waste disposition and management. These lectures, also presented under the sponsorship of the Pan American Sanitary Bureau, were attended by approximately twenty graduate students of the University and some fifty personnel of the Department of Sanitary Works.

RADIOLOGICAL HEALTH SEMINAR AT THE UNIVERSITY OF NORTH CAROLINA

On January 26 through 28, 1959, the Department of Sanitary Engineering of the University of North Carolina and the North Carolina State Board of Health will conduct their Fifth Annual Seminar on Radiological Health. Laboratory and seminar sessions will be supplemented by formal instruction by outstanding speakers from the national agencies engaged in nuclear energy control and by members of the faculty of the University. The instructional objectives of the seminar will be to provide the bases for the operational activities of control agencies and the means for developing administrative leadership in this urgent environmental health need. Information on these sessions may be secured from Professor Emil T. Chanlett, Department of Sanitary Engineering, School of Public Health, University of North Carolina, Chapel Hill, North Carolina.

* * *

SANITARY ENGINEERING RESEARCH**PUBLIC HEALTH SERVICE GRANTS FOR SANITARY ENGINEERING RESEARCH**

A recent publication of the Public Health Service (PHS No. 624) entitled "Public Health Service Grants and Fellowships Awarded by the National Institutes of Health 1958" lists many sanitary engineering research projects supported by Federal grants. These research projects reflect the types of research presently underway in most of our major universities and for this reason will be of interest to many Division members. Projects supported by Fiscal Year 1958 funds are as follows:

University of California

Air Pollutants Resulting from Combustion	\$28,000
Effect of Organic Substances from Sea on Bacteria	9,924

University of Southern California

Influence of Pollution on Marine Invertebrates	3,450
Effect of Air Pollutants on Plasma Proteins	18,000
Products of Algal Metabolism	19,336
Polychaetous Annelids as Indicators of Pollution	8,199

California Institute of Technology

Flocculent Solids in Sedimentation Basins	15,158
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University of Colorado

Shigella Dysentery Organisms in Irrigation Water	14,777
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Georgetown University

Radioisotopic Test for Bacteria	24,380
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University of Miami

Ecological Effects of Sewage	14,283
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University of Florida

Removal of the Fluoride Ion from Drinking Water	5,750
Study of Water Coagulation	5,750

ASCE	Sanitary Engineering Division	1959-3--9
University of Florida (continued)		
Acid Intermediates During Anaerobic Fermentation		\$ 8,999
Bacterial Oxidation of Nitrite		12,995
Basic Processes of Secondary Sewage Treatment		18,112
Ecology of Iron and Sulfur Bacteria		14,835
Georgia Institute of Technology		
Effect of Relative Humidity on Airborne Bacteria		13,512
-do-		26,910
Sludge Digestion Analysis by Gas Chromatography		5,244
-do-		12,645
Bactericidal and Sporocidal Properties of Chlorine		9,315
Evaluation of Samplers used in Aerobiological Studies		8,107
Illinois Institute of Technology		
Inhibition of <i>E. coli</i> in Lake Water		966
-do-		8,566
University of Illinois		
Biological Treatment of Petrochemical Wastes		7,449
Physico-chemical Properties of Milk and Cream		9,794
Water Main Carrying Capacity		20,627
State University of Iowa		
Loadings for Digested Sludge Lagoons		6,602
University of Kansas		
Seasonal Variations of Nitrates in Water Supply		1,840
Yearly Variation in Sanitary Quality of Well Water		6,095
Massachusetts Institute of Technology		
Mechanics of Waste Water Diffusion		9,833
Improvement in Sanitation by Ionizing Radiation		26,027
Complementary Effect of Heat and Ionizing Radiation		20,665
Biochemical Characteristics of Synthetic Detergents		9,200
University of Michigan		
Atmospheric Pollution by Aeroallergens		68,409
-do-		2,111
Study Section Research Sanitary Engineering and Occupational Health		15,000
-do-		5,000
Wayne State University		
Phenolic Compounds in Urban Air		16,862
Michigan State University		
Toxicity of Cadmium in Water Supplies		21,045
Protective Coatings for Water Distribution Systems		10,000
High-rate Composting of Organic Wastes		14,000
University of Minnesota		
Composition and Movement of Soil Gases		10,000
Factors Affecting the Anaerobic Contact Process		503
-do-		28,676
-do-		1,649

University of New Hampshire	
Enterococci as Indicators of Water Pollution	\$ 5,469
Rutgers University	
Degradation Products of Sewage	5,462
Purification in the Activated Sludge Process	5,778
Determination of Residual Chlorine in Wastes	4,915
Biochemical Oxygen Demand of Organic Compounds	4,428
Death of Bacteria in Sew Water	3,622
Cornell University	
Fate of Surfactants in Water	5,129
Haskins Laboratories, Inc.	
Nutrition of Planktonic Microorganisms	14,000
Manhattan College	
Oxygen Transfer Coefficient in Biological Oxidation	9,684
New York University	
Synthetic Detergents in Activated Sludge Process	7,590
Determination of Nitrate Nitrogen in Sewage	6,900
Fundamentals of Controlled Sewage Filtration	16,215
University of North Carolina	
Mechanism of Coagulation of Colloids	5,640
-do-	273
Oxygen in Waste Treatment	1,109
-do-	8,963
North Carolina State College	
Color Removal from Streams	9,228
Ohio State University Research Foundation	
Aquatic Bacteria Related to Acid Mine Drainage	7,711
Oregon State College	
Resistance of Marine Animals to Pollution	11,159
Bloom Production Related to Plankton in Bottom Sediments	5,244
Influence of Dissolved Oxygen upon Freshwater Fishes	13,618
Toxicity of Pulp Mill Wastes to Fish	1,926
Academy of Natural Sciences, Philadelphia	
Toxicity of Certain Chemicals in Water	14,286
University of Pittsburgh	
Electrochromatography in Air Pollution	7,475
Pennsylvania State University	
Design Criteria for Sludge Treatment of Sewage	14,910
North Texas State College	
Morphology, Taxonomy and Ecology of Actinomycetes	14,005
University of Texas	
Sanitary Aspects of Sewage Sludge and Compost	14,829
Utah State University	
Effects of Insecticides on Health	33,062
Toxicity of Fluorides to Fresh-water Fish	12,995

ASCE	Sanitary Engineering Division	1959-3--11
University of Vermont		
Nutritional Requirements of Green Algae		\$ 6,388
Washington State College		
Characteristics of Anaerobic Digestion		3,338
University of Washington		
Effect of Lakewater Pollution on Algae Growth		10,421
Determination of Phosphate in the Atmosphere		5,768
University of Wisconsin		
Nutrition and Physiology of Blue-green Algae		15,605

In reviewing the section of this report related to research fellowships it was noted that only two research fellowships were awarded to sanitary engineers. One went to the University of Illinois and the other to Washington University in St. Louis. Both were for post-masters study.

Copies of PHS Publication No. 624 can be obtained from the U. S. Government Printing Office, Washington 5, D. C. for 75 cents per copy.

DIVISION RESEARCH COMMITTEE MEETS TO DISCUSS BASIC RESEARCH

Dr. Nelson L. Nemerow, Chairman of the Sanitary Engineering Division's Research Committee, has provided the News Section with a summary of the Committee's deliberations at the recent Basic Research Conference in Washington, D. C. on Sept. 11, 1958.

The Committee decided that a change in procedure is desirable at this time. Involved are two subjects of immediate and vital concern:

1. The decision was made that in the future the Committee's efforts would be directed towards obtaining written papers on valuable current research from others rather than prepare research reports itself. Committee discussion and evaluation will be appended to the papers prior to submission to the Publications Committee.
2. The Committee decided to submit one complete research project proposal to the Society's Research Committee for financial support.

In its report to the Basic Research Conference, the Sanitary Engineering Division Research Committee indicated that its purpose is to assist in communicating basic research to the engineer through published reports, evaluate current research, stimulate needed research, assist in obtaining research sponsorship, and to suggest papers for technical programs.

Areas requiring research were cited as follows:

Sewage

Tertiary treatment to remove dissolved minerals which would lead to a water capable of being reused.

Water

Water from the sea for everyone.

Stream Pollution

Problems of multipurpose storage reservoirs for supply; gradual dissolution of riparian rights law and replacement by a prior appropriation doctrine.

Industrial Wastes

Movement to eliminate process chemicals having high BOD; recovery of valuable by-products (formerly pollutants); heat dry waste liquors and sludges; better correlation between stream needs and degree and type of waste treatment for new organics; safe, practical, and economical methods for removing radioactive materials.

Air Pollution

Effect of air contaminants upon health; control of air pollution in all types of weather.

Public Health

Radiation tolerances (water, air, and food).

Refuse

Develop research design criteria for incinerators; more effective use of all types of available land for sanitary landfills.

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WATER SUPPLY AND WATER POLLUTION CONTROL**BECK OF ALABAMA AND LYON OF PENNSYLVANIA SCORE ON PUBLIC AWARENESS**

Arthur N. Beck, Technical Secretary of the Alabama Water Improvement Commission and Walter A. Lyon, Chief of the Division of Sanitary Engineering, Pennsylvania State Department of Health, are to be congratulated for the excellent published reports on water pollution control in their respective states. Both are colorful, informative documents and will be of great value in creating increased public awareness of the water pollution control problems in Alabama and Pennsylvania.

Engineers as a group have not always been blessed with a full appreciation of the need for utilizing imaginative and professional public awareness techniques in support of needed public works. Water pollution control is certainly no exception. More publications of the quality developed by Alabama and Pennsylvania are needed. Information regarding these reports can be obtained by writing the following:

Mr. Arthur N. Beck, Technical Secretary
Alabama Water Improvement Commission
State Office Building
Montgomery 4, Alabama

Title of report: "Streams of Progress"

Mr. Walter A. Lyon, Chief Division of Sanitary Engineering
Pennsylvania State Department of Health
P. O. Box 90
Harrisburg, Pennsylvania

Title of report: "A Report to the People of Pennsylvania—Your Clean Streams Program"

REVISION OF 1946 DRINKING WATER STANDARDS

The general acceptance of the PHS Drinking Water Standards makes it mandatory that they be kept current and that the basic knowledge required to deal with new problems be developed before problems become acute. During the past 15 years, the development of atomic energy, accelerated industrial expansion, and rapid technological advances have outmoded the present Standards in some aspects. Available new knowledge will make possible the expansion of the existing Standards.

An advisory committee on revision of the 1946 PHS Drinking Water Standards, now being appointed, will consist of representatives of the following agencies and scientific and professional organizations: Food and Drug Administration, U. S. Geological Survey; American Chemical Society; American Public Health Association; American Society of Civil Engineers; American Water Works Association; Association of American Railroads; Air Transportation Association; Conference of State Sanitary Engineers; Association of State and Territorial Public Health Laboratory Directors; Society of American Bacteriologists; National Committee on Radiation Protection; National Bureau of Standards; American Medical Association; American Dental Association. The names and members and the first meeting date will be announced in the near future. The committee will be asked to review and make recommendations on the drafts of the revision now being prepared by a technical subcommittee of Public Health Service Officers.

8TH SOUTHERN MUNICIPAL AND INDUSTRIAL WASTE CONFERENCE

Announcement has been made of the 8th Southern Municipal and Industrial Waste Conference to be held at the University of North Carolina, Chapel Hill, North Carolina, on April 2-3, 1959. The conference is also sponsored by Duke University and North Carolina State College.

Technical sessions will feature "Solids Separation Processes," "Chemical and Biological Treatment" and "Solids Handling and Disposal." For information write to Dr. Daniel A. Okun, Department of Sanitary Engineering, School of Public Health, University of North Carolina, Chapel Hill.

PUBLIC HEALTH SERVICE RELEASES REPORT ON WATER POLLUTION CONTROL

The Public Health Service has released a report on its water pollution control program for the fiscal years 1957 and 1958. It covers all phases of the program—construction of sewage treatment plants, interstate enforcement activities, research and basic data analyses, and the need for increased public awareness of the water pollution problem. The country's water pollution problem was recently described as "ominous" by Arthur S. Fleming, Secretary of Health, Education and Welfare. He added that a sustained and vigorous attack on water pollution in this country is a "must."

The document may be obtained from the Water Pollution Control Program of the Public Health Service in Washington, or from the Service's Regional Engineers in the following cities:

Region I and II—Room 1200, 42 Broadway, New York 4, New York; Region III—700 East Jefferson Street, Charlottesville, Virginia; Region IV—Room 164, 50 Seventh Street, N. E., Atlanta 23, Georgia; Region V—Room 200, 69 West Washington Street, Chicago 2, Illinois; Region VI—2305 Federal Office

Building, 911 Walnut Street, Kansas City 6, Missouri; Region VII—Ninth Floor, 1114 Commerce Street, Dallas 2, Texas; Region VIII—Room 551, 621 17th Street, Denver 2, Colorado; Region IX—447 Federal Office Building, Civic Center, San Francisco 2, California.

SHUTDOWN OF LIMESTONE WASHERY HAS ADVERSE EFFECT ON ACID STREAM

The Pennsylvania Department of Health, normally anxious to keep waste out of the state's streams, recently reported this abnormality: it's sorry to see a limestone washery stop its discharge into Slippery Rock Creek.

Here's the reason: the discharge from the limestone mine and washery located in Marion Township (Butler County) neutralized the acidity of the coal mine drainage water that also flows into the creek. The limestone mine and washery have gone out of business, and analyses of water samples taken from various locations on the watershed above and below the plant show that the stream one mile below the limestone plant has become acid whereas it was previously alkaline.

POLLUTION CONTROL EXHIBIT WINS TOP HONORS AT A.P.H.A. MEETING

One of the eight exhibits selected by the judging board of the American Public Health Association at its 86th Annual Meeting in St. Louis as outstanding from 150 technical and scientific exhibit entries was one designed to show the value of water pollution control. Prepared by the Pennsylvania Department of Health, this exhibit illustrated how an area, blighted by water pollution, can become attractive to both industry and sportsmen after pollution has been eradicated through industrial and municipal waste treatment plants.

COAGULANT AIDS APPROVED FOR USE IN TREATMENT OF PUBLIC WATER SUPPLIES

The Public Health Service's Technical Advisory Committee on Coagulant Aids for Water Treatment held its fifth meeting September 26, 1958, at the Robert A. Taft Sanitary Engineering Center in Cincinnati. Four coagulant aids were reviewed.

On the basis of information submitted by the manufacturer, the Committee concluded that these products can be used for treatment of public water supplies with no adverse physiological effect upon water consumers when used in recommended concentrations, and provided that they continue to meet the quality specifications furnished the Committee. The four commercial aids considered included:

<u>Manufacturer</u>	<u>Product</u>	<u>Maximum Concentration Recommended by Mfg. (p.p.m.)</u>
Kelco Company	Kelgin W and Kelcosol	2
The Burtonite Company	Burtonite # 78	5
Hagan Chemicals & Controls, Inc.	Coagulant Aid # 2	1

The Committee emphasized that its findings bear only on the health aspects of the use of these products and do not constitute endorsement or indicate effectiveness in proposed use.

The following products have been previously reviewed by the Committee and found to conform to Committee Requirements:

<u>Manufacturer</u>	<u>Product</u>	<u>Maximum Concentration Recommended by Mfg. (p.p.m.)</u>
Allyn Chemical Company	Claron	1.5
E. F. Drew & Co., Inc.	Drewfloc	1.8 alum
		0.5:10 lime
Hagan Chemicals & Controls, Inc.	Coagulant Aid # 7	0.75
	Coagulant Aid # 11	4
	Coagulant Aid # 18	15
Hercules Powder Company	Carboxymethylcellulose	1
The Permutit Company	Permutit # 65	2
	Permutit # 66	2
	Permutit # 67	4
Stein, Hall & Company	Jaguar	0.5

SHELLFISH SANITATION RESEARCH LABORATORY OPENS ON WEST COAST

With the opening of the first Pacific Coast shellfish sanitation research laboratory at Purdy, Washington, the Robert A. Taft Sanitary Engineering Center has extended a branch of its operation to the West Coast. The work on the sanitary bacteriology of harvesting, processing, and marketing of commercial shellfish is being done cooperatively with the Washington State Health Department, the producing states, and the Public Health Service in the interest of the consuming public.

The installation at Purdy, erected with the aid of a Washington State appropriation of \$40,000, includes marine experimental, bacteriological, and chemical laboratories plus office and service facilities. The four-man research team, headed by C. B. Kelly of the Center staff, has worked together for nine years, four at Woods Hole, Mass., and five at Pensacola, Florida.

BOX SCORE ON SEWAGE TREATMENT WORKS GRANTS

As of October 31, 1958, 1266 projects had been approved, 594 of these were under construction, and 280 completed. Ratio of local funds to Federal continues at more than 4 to 1. Over 80 per cent of all projects involve new plant construction required for the abatement of long-standing pollution problems.

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SOLID WASTE DISPOSAL

SECOND EDITION OF REFUSE COLLECTION PRACTICE NOW AVAILABLE

The second edition of Refuse Collection Practice has recently been published and is available from Public Administration Service, 1313 East 60th Street, Chicago 37, Illinois. The price is \$8.00 and the book is worth every penny of it.

Prepared by the Committee on Refuse Collection of the American Public Works Association, it is a practical manual covering the many facets of the

problem—the kinds and amounts of community refuse materials and their preparation for collection; costs, methods, and equipment; planning the collection system; municipal, contract, or private collection; and the management problems of financing, organization, personnel, equipment management, reporting, cost accounting, budgeting, and public relations.

The Committee on Refuse Collection first gathered information on the practices of more than 900 cities of over 5,000 population throughout the United States and Canada. It then forwarded a detailed questionnaire to 125 cities selected by the members of the Committee as able to provide the most accurate and complete information on operations, quantity, and costs. Of this group, 89 cities responded, ranging in population from 13,000 (Winnetka, Illinois) to over 8,000,000 (New York City). All data reported are of experience in 1955 or later.

The U. S. Public Health Service cooperated in the preparation of the book through provision of technical assistance, particularly in the tabulation and analysis of the data contained in the returned questionnaires.

Members of the Refuse Collection Committee of the APWA were: Warren A. Schneider, Chairman, Director, Bureau of Sanitation, Department of Public Works, Los Angeles; Ralph C. Taylor, Superintendent, Waste Collection Division, Department of Public Works, Cincinnati; Theodore C. Eppig, Deputy Commissioner, Department of Streets and Sanitation, Chicago; Henry L. Giles, Deputy Director, Department of Public Works, Hartford, Conn.; Walter Bonnet, Engineer, Corps of Engineers, Washington, D. C.; Stanley I. Pinel, Consultant, Washington, D. C.; Dale N. Garst, Sanitation Director, Department of Public Works, Wichita, Kansas; and Leo Weaver, Secretary, Director of Research, American Public Works Association, Chicago, Illinois.

Mr. Edward Williams, Chief of the Refuse Sanitation Unit, Technical Services Section, General Engineering Program, Public Health Service, has reviewed this book for the Journal and made the following comments:

"The revision of this manual by the APWA Refuse Collection Committee is a substantial contribution toward better refuse collection practice in this country. This text stands alone in its field as a guide by which cities and especially smaller communities can pattern efficient and sanitary collection systems and will be useful to officials concerned with planning refuse collection services in our rapidly growing suburban areas. The person with it on his desk has the benefit of observing collection practices in hundreds of American cities and the opinions of scores of our most experienced men in this field. Along with presenting the more progressive and economical procedures in current use the pitfalls to be avoided are pointed out in designing or operating a collection system.

"The Appendices in this manual will probably be found as useful as the text. The typical ordinances have been brought up to date, data from an extensive survey on current practices and costs in American cities are summarized and a valuable addition has been made in the Analysis and Planning of Refuse Collection Systems. For the person looking for additional information the latest references are included in Appendix E, Selected Bibliography.

"A vote of appreciation for the many hours of personal time and effort spent by the Committee in performing this public service."

-Edward Williams

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AIR POLLUTION

REGISTER OF AIR POLLUTION ANALYSES AVAILABLE

The Register of Air Pollution Analyses, containing a listing of more than 100 different chemically definable individual pollutants or constituents of mixed pollutants found in the air above 200 cities in 32 states and territories, is now available from the Superintendent of Documents, U. S. Government Printing Office. Among the information catalogued in the Register are location, category, dates, length of sampling, prior frequency of sampling, type of equipment, and method of analysis. The Register contains a record of the names and addresses of 95 air pollution control agencies, health departments, universities, and research institutions in the states and territories known to have performed community air sampling and analyses prior to January 1, 1956.

PRESIDENT ISSUES AIR POLLUTION ORDER

President Eisenhower has recently issued Executive Order 10779 directing Federal agencies to cooperate with state and local authorities in preventing air pollution. This action, which was taken to "preserve and protect the primary responsibilities and rights of the states and local governments in controlling air pollution," is comparable to an earlier order issued on water pollution. Involved here is the recognition that certain federal activities have not complied with the abatement programs authorized by state and local law. The order directs cooperation with local authorities to insure the prevention of air pollution caused by such activities as industrial and manufacturing processes operated or controlled by the federal government.

NATIONAL CONFERENCE ON AIR POLLUTION

More than 70 air pollution specialists, civic leaders, and representatives of industrial and governmental agencies dealing with air pollution problems were on the program of the National Conference on Air Pollution held in Washington, D. C., in November.

The conference, called by Dr. L. E. Burney, Surgeon General of the Public Health Service, met at the Sheraton-Park Hotel in Washington November 18-20 to enable air pollution specialists and civic and industrial leaders to review recent knowledge about the air pollution problem and to recommend plans for dealing with it. Dr. Burney opened the meeting with a status report to the nation, summarizing the progress that has been made since the enactment of the first federal air pollution control legislation in 1955. Secretary of Health, Education, and Welfare Arthur S. Flemming spoke at the final day's session on the relation of air pollution control to future progress.

Other speakers on the program included Martin Agronsky, noted news commentator, who summarized the Conference discussions; Dr. Edwin D. Harrison, president of the Georgia Institute of Technology, who spoke at the Conference banquet on November 18; and Chauncey D. Leake, representing the American Association for the Advancement of Science, who discussed the social aspects of air pollution.

Public officials appearing on the program included Senator Thomas H. Kuchel of California, who developed the Federal legislation on air pollution; Mayor Raymond R. Tucker, St. Louis; Dr. Herman E. Hilleboe, New York State Commissioner of Health; and Dr. Malcolm H. Merrill, director of the California Department of Public Health.

Among those speaking on the industrial role in air pollution control were General John E. Hull, president of the Manufacturing Chemists Association; Max D. Howell, executive vice president of the American Iron and Steel Institute; Harry A. Williams, managing director of the Automobile Manufacturers Association; and Dr. Jerry McAfee, chairman of the smoke and fumes technical advisory committee of the American Petroleum Institute.

During the second day of the Conference, group sessions were held to discuss the six major topics of the Conference, namely: the extent of air pollution; its sources; its health effects; its economic and social effects; methods of control; and administrative aspects.

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